TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

DEVAYANI KULKARNI

INTERNET OF THINGS IN FINNISH METAL INDUSTRY

Master of Science thesis

Examiner: Professor Nina Helander

Devayani Kulkarni

ABSTRACT

Devayani Kulkarni: Internet of Things in Finnish metal industry
Tampere University of Technology
Master of Science Thesis, 53 pages
March 2018
Master's Degree Programme in Business and Technology
Examiner: Professor Nina Helander

Metal industry plays a vital role in the economy of any country. It is due to the wide range of customers that this industry serves including mechanical engineering, construction, automobile etc. Metal industry has always been stronger industrial area for Finland and has served as one of the biggest employers. Although there are big names associated with Finnish metal industry, the industry is mainly dominated by SMEs. Changing market demands, high level of quality expectation and at the same time need to ensure lower operational costs, are forcing companies in metal industry to evaluate and improve business processes.
Finland has always been ahead of time when it comes to digitization, including research activities, government support and deployments of new technologies. This has ensured the basic IT infrastructure, availability of internet across all industries in Finland, creating a pro-digitization setup. Internet of Things (Iot) and Industrial internet of Things (IIoT) technologies are standardizing in recent couple of years. The successful deployments of IIoT are encouraging and have proven the economic, social, environmental value that it creates, making a good basis for Finnish metal industry to adopt IIoT.
This paper focuses on recent developments in IoT and value created by IoT in the context of metal industry. Since confidence on newer technologies like IoT increases with success stories, case study was the most suitable research method for this research. ABB, one of the major player in IIoT space was considered the case company for this research.
The research concludes that the value could be created by predictive maintenance and automation, to overcome major challenges in Finnish metal industry and IoT platforms could help SMEs, which makes the major part of Finnish metal industry, for IoT adoption.

Devayani Kulkarni

PREFACE

Being a software professional for about fifteen years I have seen developments in the software creation and the value it is been creating for businesses. The master's program that combines the knowledge of technology with business is a great help to figure out the right business opportunities that newer technology developments like IoT, are creating in different industries. I observed during this thesis writing that the technology industry is majorly driving also the business research to push the new standards with IoT development. This thesis has broadened my view on IoT space, than it was before, still a long way to go though!
I must thank my supervisor, Professor Nina Helander for her valuable feedback during the whole process. Many times, I felt lost in the pool of information on the internet and always a meeting with Professor Nina has guided me in right direction. She has motivated me for completion of my work and I am very thankful to her! I want to thank my family, specially my beautiful daughters for being patient with my long working hours and my friends for all the encouragement!

Tampere, March 2018

Devayani Kulkarni

TABLE OF CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

Technological advances have driven dramatic increases in industrial productivity since industrial revolution. First industrial revolution with the steam engine powered factories was in the nineteenth century. Second industrial revolution was triggered by electrification that led to mass production in the early part of the twentieth century. Third revolution made the industry automated in the 1970s. In the decades that followed, however, industrial technological advancements were only incremental, especially compared with the breakthroughs that transformed IT, mobile communications, and e-commerce. But in recent decades industries are undergoing a change that is every bit significant and drawing attention from innovators and investors all over the world. The new digitally-enabled technology that includes advances in production equipment, smart finished products and data tools and analytics can help to build facilities that need almost no human help to do their jobs and can collect huge amounts of data along the way. Supervisors can get instant alerts about potential problems from intuitive user interfaces accessible on-go and can study the numbers to find ways to boost efficiency and improve performance.

Metal industry plays a vital role in the growth of any country being one of the basic industries. Metal industry has been valuable for Finland from centuries. According to Association of steel and metal producers (Järvinen, 2016), metal industry's enterprises employ 17,000 people in Finland and have a turnover of EUR 9.5 billion. The Finnish metal processing industry is famed for its highly efficient use of energy and raw materials. In some processes Finnish metal processing enterprises are the global leaders. More than half the copper and a third of the nickel used globally is made using a flash smelting method developed in Finland, which self-generates the energy required in the process ((Järvinen, 2016).

Finland has always been ahead in time when it comes to adapting digital processes. About metal processing industry such as steel industry, digitization has moved from being an augmenting capability to something that is a disruptive force. Delivering supply chain agility, deeper process understanding and higher production utilization are becoming important issues. Automation is combining with data analytics to enable much higher flexibility as well as more efficiency in production. Algorithms are linking the physical properties of the materials with production costs and plant constraints to improve efficiency. Processes that were previously separated are now being integrated, leading to reductions of heat loss, energy consumption, throughput time, inventory as well as better price optimization. Most of the infrastructure in Finnish metal industry is digitalization supportive, however; there is still a lot of scope to enhance performance and optimize processes with more digital integration in traditional industries like metal industry. This paper focuses on the recent developments in industry digitization, specially Internet of Things (IoT) that can add value to Finish metal industry.

ABB, for over a decade have been working to develop and enhance process control systems, communications solutions, sensors and software for the IoT. These technologies enable ABB's customers in industries, utilities and infrastructure to analyze their data more intelligently, optimize their operations, boost their productivity, and their flexibility. ABB Group has been demonstrating IoT deployments in many of its industries, making it a good example to study. Key deployments and services include:

- Monitoring more than 5,000 robots in service around the world
- Monitoring Gearless Mill Drives in mines
- Introducing ABB's Yumi in 2015, the world's first collaborative robot, capable of interacting with the environment, humans, other robots and machines

Hence this paper considers ABB as a case study to put forth the example of how IoT integration adds value to metal industry.

1.2 RESEARCH QUESTION

In recent decades digitization of industry is becoming primary goal for many organizations. The traditional manufacturing business model is changing, and new models are emerging; incumbents must be quick to recognize and react to new competitive challenges. In last few years Internet of Things has come across as demonstrable technology also in manufacturing and processing industry with successful deployments and visible value add by bringing together brilliant machines, advanced analytics, and people at work. The network of a multitude of devices connected by communications technologies that results in systems that can monitor, collect, exchange, analyze, and deliver valuable new insights like never before. These insights can then help drive smarter, faster business decisions for industrial companies.

The research problem of the study is:

How can IoT add value to metal industry in Finland considering ABB as a case study?

The research problem shall be solved by answering following questions:

- What are digitization needs of Finnish metal industry?
- How IoT adds value to manufacturing and processing industry?

- Case study: ABB – how ABB and it's IoT platform - ABB ability, helping companies in metal industry achieve higher productivity.

1.3 Research Context

This research is primarily focused on business to business context. In recent couple of years there is lot of discussion around the term IoT, its feasibility and deployments. Along with the technological advancements in the field of IoT, plenty of research is being conducted for IoT applications in business to business context.

The confusion around IoT is getting clear slowly, however there are many overlapping terms when the general discussion about digitization starts.

Following figure shows some of the terms that are used in context of digitization.

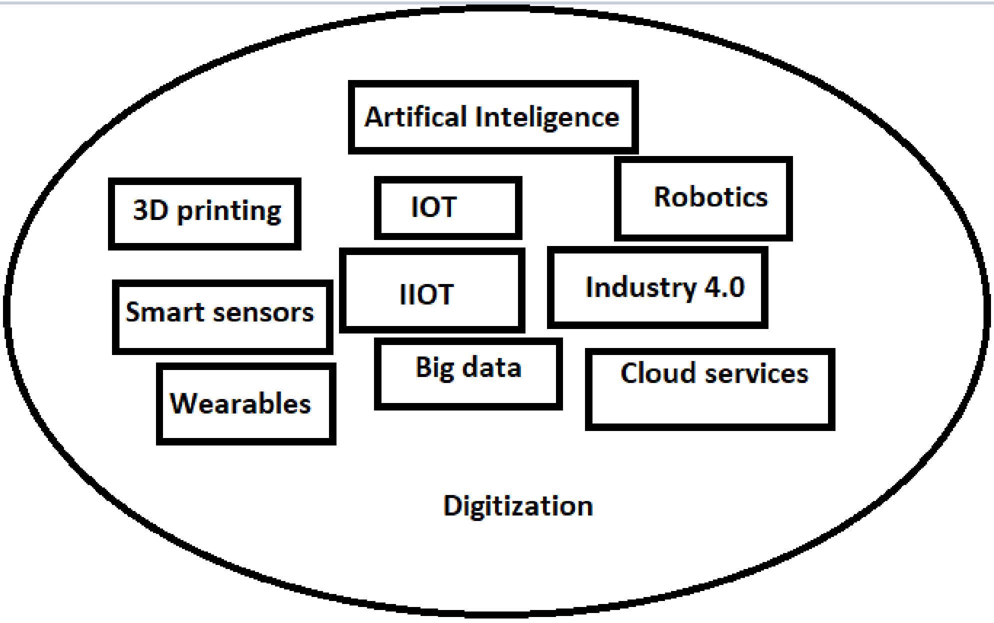

Figure 1, Terms refered in the context of digitization.

GE refers the term 'Industrial internet', which means IIoT i.e. Industrial Internet of Things. ABB expands IoT to IoTSP, involving services and people as part of internt of things.

In the context of this research the term digitization is the bigger umbrella that covers all the technologies and strategies that enable modernization of industry in the ira of IoT. The thesis in the later part covers the specifics of IoT and IIoT, however since the research is mainly focused on metal industry, all the terms in the figure 1 are some or the other way relevant.

1.4 RESEARCH METHOD USED AND RESEARCH PROCESS

The research method used for this paper is use of existing material, qualitative document analysis and case study. Use of existing material is usage of anything that has been published either online or printed on paper for data. Anything from the review of previous literature to analysis of existing available data can be used as existing material (Gummesson, 1993).

Researcher Robert K. Yin defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 1984, p. 23). This gives rise to three important things needed for a case study 1) Empirical inquiry with evidence 2)A phenomenon in real life context and 3) Relationship between these two.

Case studies are commonly used in organizational studies. According to Yin (2003), the distinctive demand of case studies comes from the desire to understand complicated social phenomena. The reason is that the case study method permits researchers to retain the comprehensive characteristics of events such as organizational and production processes. Case studies provide analytical generalization of theories and it covers a wide range of research methods and techniques including qualitative research method. Case study research, through reports of past studies, allows the exploration and understanding of complex issues. It can be considered a robust research method particularly when a holistic, in-depth investigation is required. Through case study methods, a researcher is able to go beyond the quantitative statistical results and understand the behavioral conditions through the actor's perspective. By including both quantitative and qualitative data, case study helps explain both the process and outcome of a phenomenon through complete observation, reconstruction and analysis of the cases under investigation (Tellis, 1997).

Once the theoretical part of data collection is done, second part of case study is a phenomenon in real life. An actual implementation of the research topic in the real world which should answer the question "how" or "why". It should also give the reason why at all this research is being conducted. And third most important part is relating the theoretical framework with the real-life context in a convincing way to support the result with evidence of case study.

ABB is the chosen case company for this research. ABB is ASEA Brown Boveri, a Global 500 company head-quartered in Switzerland, and one of the world's largest engineering companies. ABB is a Swedish-Swiss multinational which is, among others, active in energy and automation. One of the main activities of the company is the production of industrial robots and manufacturing services for a variety of industries, ranging from automotive to electronics and, increasingly, the food industry making $33.8bn last year and employing 132,000 people. Such industrial robots are indeed not the kind of robots seen at the Consumer Electronics Show but robotics systems as they are mainly used for manufacturing. On top of making and selling such industrial robots, ABB provides a series of services.

The topic of this research is relatively new. Data were collected from public, non-confidential information. The main sources of information were mostly press releases along with articles, books and credible websites.

For finding the relevant data, some specific keywords were used. The keywords are 'internet of things', 'process optimization', 'industrial internet of things', 'metal industry'. Result of using a single keyword was a large amount of paper which were not all related to this study. Combining keywords helped to narrow down the findings to the most relevant papers.

The research flow for this paper is as shown in below.

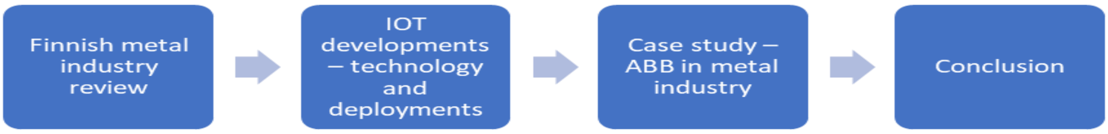

Figure 2. Research process

Background study: Studying the information available on web and existing literature about the metal industry, Finnish metal industry and in general the possible bottlenecks related to digitization in this industry.

Technology support study: There have been significant innovations in IoT technologies and major deployments in in the industry in last couple of years. Studying the current offerings of Industrial Internet of Things, the theory part is covered as this part of the paper.

Case study - ABB: ABB has been working over IoT integrations in all its industries for over a decade and so putting forth a good example to refer to when it comes for IoT integrations for metal industry as well. The case study focuses on ABB's IoT success stories in metal industry. Information available on web is used to for the case study.

Conclusion: Based on the IoT needs of Finish industry and ABB's example conclusions are drawn for IoT integration in Finish metal industry.

2 METALS INDUSTRY

2.1 INTRODUCTION

Control over metal supply to the economy has been considered vital for political and economic reasons in most societies. In the recent decade, the demand for metals has been increasing significantly globally, mainly due to the rapid industrialization. Metals industry can be considered to be made up of sub sectors such as metal production, metal products and target market where the metal products are used e.g. companies producing metal products needed for building and construction industry.

The metals production industry is concerned with the extraction of metals from mineral ores. This is achieved through a variety of different process paths that depend on the metal that is being produced. In general, ores are processed to remove impurities and increase the concentration of the valuable mineral. This concentrate then undergoes smelting to produce a crude metal which is then refined further to achieve the required purity for the final product. (David M, 2005)

Metal industry, although it includes a number of large companies, the sector is dominated by SMEs acting as sub-suppliers to industries as diverse as automotive, aerospace, mechanical engineering, transport, construction and food. They are very well integrated into industrial supply chain.

2.2 FINNISH METAL INDUSTRY

2.2.1 History

The metal industries led Finland's post-war economic development, and they were crucial to the country's economic health. Until World War II, Finland generally produced relatively unsophisticated goods for domestic consumption. The country's shortages of energy, basic metals, and capital accounted for the sector's slow development. Although Finland had produced ships and other capital goods for the Russian market since the late nineteenth century, the real breakthrough came after 1944. Then the metalworking industry, goaded by Soviet reparations demands, overcame its handicaps, sharply increasing both the quantity and quality of output. Reparations deliveries ended in 1952, but the Soviet Union continued to absorb Finnish metal goods. By the late 1950s, Finland had built an efficient and innovative metalworking sector. In the 1960s, the metalworking sector, stimulated by the effects of trade liberalization, embarked on an export drive in Western markets. Domestic demand rose as a result of both the expansion of the forest and the chemical industries and major infrastructure projects. Throughout the 1960s and the 1970s, the sector prospered, growing at an average annual rate of over 6 percent, higher than the rates of other industrial sectors. The strategy of specializing in a small number of products in which the country already possessed a comparative advantage paid off in export markets. Finnish design, which integrated ergonomics, durability, and attractive appearance, also helped maintain sales. Thus, the sector was relatively well prepared to respond in the 1970s, when rapid increases in energy prices, competition from newly industrialized countries, and worldwide improvements in capital-goods technologies threatened profitability.

Beginning in the mid-1970s, metalworking, like the forest industries, underwent a period of intense rationalization and restructuring--with only limited state help. By the late 1980s, it appeared that the sector was well on the way to transforming itself to meet the conditions of high energy costs. Indeed, metalworking grew faster in Finland than it did in most industrialized countries, and it remained Finland's leading industrial sector.

The metal industry is one of Finland’s flagships in terms of the significance of its exports, professional competence, and product development. This is an extremely diverse sector; successful products in this field include cruise ships, engines for ships and power plants, pulp and paper machines, rock and mineral processing equipment, lifts, cranes and working platforms, and agricultural and forestry machinery. In addition to manufacturing of machinery and equipment, Finland is home to high-quality metal subcontracting and parts manufacture. Finnish metal companies manufacture and process steel and copper products, refined steel, zinc and nickel. The Business is shifting towards even more highly processed specialty products and related services. In this sector, expertise, automation and the efficient use of the newest technologies take center stage. (Järvinen, 2016)

2.2.2 Statistics

Metal industry in Finland has become the largest industrial sector both in terms of exports and as an employer. As fraction of Finnish exports, the metal industry accounts for more than two fifth. In Finland there are approx. 200 certified companies operating in the metal Industry. All the large companies that have export have a certificate. (Johannes K & Hans J, 2012)

Following graph from statistics Finland, shows the production volume trend of metal, mechanical engineering and Electronics and Electro-technical industry. Based on the numbers, shares of turnover in 2014 was: mechanical engineering 52 %, electronics and electro-technical 29 %, metals industry 19 % .

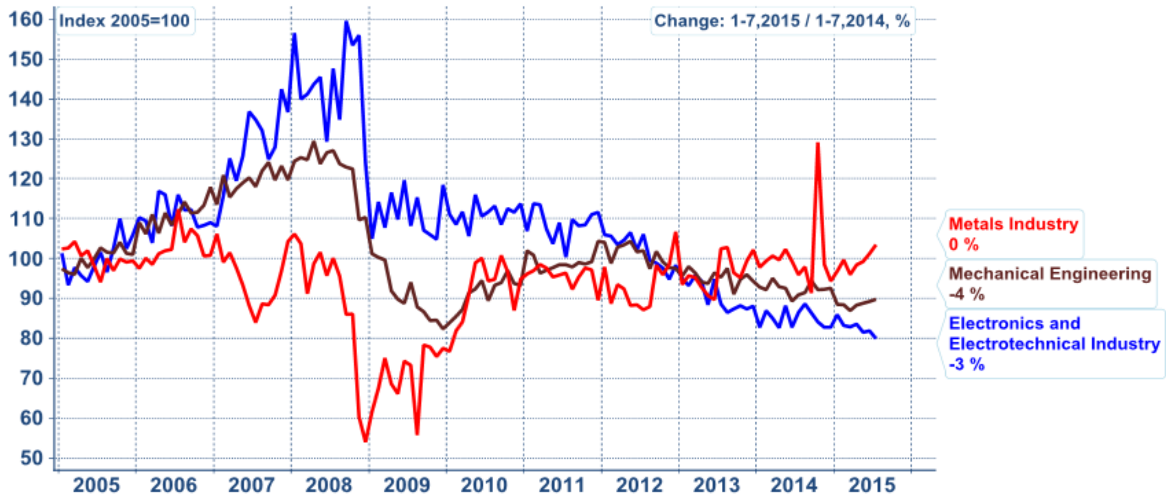

Figure 3, Production volume trend of technology sector of Finland Seasonally adjusted volume index. (Source : Macrobond , statistics Finland, 2013)

From metal industry, shares of turnover in 2013 was iron and steel products and non – ferrous metals 88 %, mining of metal ores 9 %, castings 3%. Indicating that metal industry is one of the important contributors of Finnish technology sector and from metal industry steel products and non-ferrous metals are the major companies.

Following graph shows the turnover shares of technology industries.

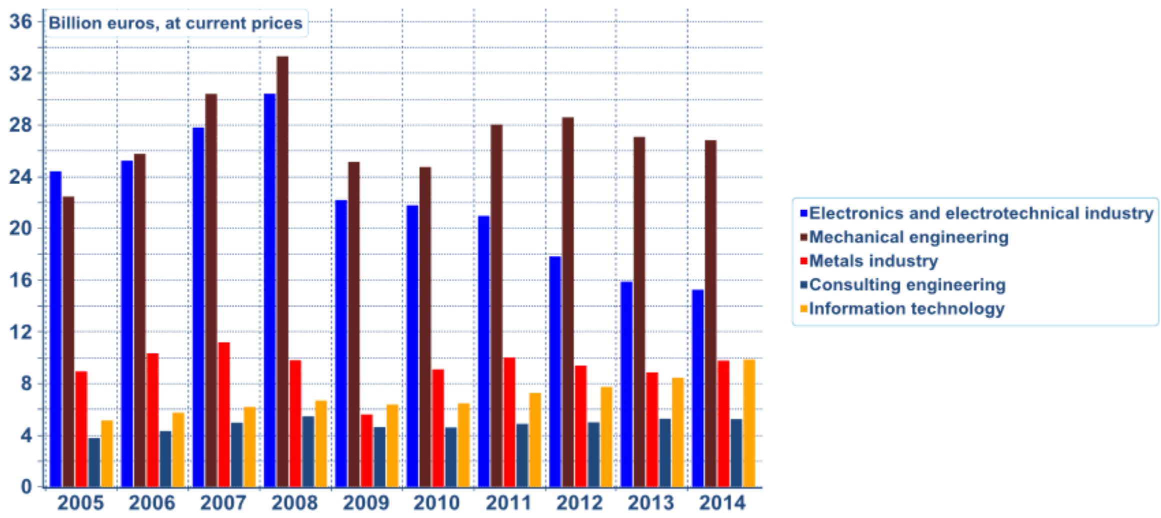

Figure 4, Turnover share of industries in Technology sector, Finland Seasonally adjusted volume index. (Source : Macrobond , statistics Finland, 2014)

Based on the numbers from Statistics Finland, the turnover of metals industry companies (steel products, non- ferrous metals, castings and metallic minerals) in Finland was EUR 9.1 billion in 2014, growing by three per cent from 2013. In 2007, prior to the financial crisis, the corresponding figure was EUR 11.2 billion.

The total production of steel products, non-ferrous metals, castings and metallic minerals in Finland increased by four per cent last year. Production between January and February 2015 was slightly lower than in the corresponding period in 2014, but turnover grew. In 2014, the number of personnel employed by Finnish metals industry companies decreased by three per cent, or 500 employees. On average, the industry employed 15,300 people in 2014. At the end of March, the number of personnel came to 15,000, slightly less than the 2014 average. In 2008, the industry employed a total of 18,100 people in Finland (Report from Technology Finland, 2014)

According to Airaksinen (1992), many facts suggest that Finnish industry has both the technological knowhow and price competitiveness necessary for exploiting new export opportunities and for defending markets at home. For a long time now, exports by the Finnish metal and engineering industries have been steadily gaining market shares in the imports and have developed several international areas of specialization and know how where Finnish companies have a significant world market share and a recognized position. Many of the Finnish metal and engineering industry companies have strengthened their marketing and competitiveness in by major foreign acquisitions and cooperation agreements. Apart from this, they have good price competitiveness as well.

2.2.3 Metal Production Industry in Finland

Over decades, there have been changes in the production of concentrates and metals in Finland. Only ferrochrome is made totally from domestic ore. Iron ore concentrates and pellets are supplied by Swedish and Russian mines. Zinc, copper and nickel concentrates are mainly imported from several sources around the world. The volume of metals production in Finland has grown constantly and the growth will continue in the near future.

The Finnish metal industry is famed for its highly efficient use of energy and raw materials. In some processes Finland is the global leader. More than half the copper and a third of the nickel used globally is made using a flash smelting method developed in Finland, which self-generates the energy required in the process. The production of metals is an important industrial sector in the Finnish national economy. The main metals produced in Finland are steel, stainless steel, zinc, copper, nickel and scrap-based aluminum. In addition, other metals like cobalt, cadmium, molybdenum, mercury, selenium, silver and gold are produced. Production of zinc, copper and nickel is based on ore. The production units are modern and their technological levels correspond to best available techniques (Fugleberg, 1999; Riekkola-Vanhanen, 1999a,b,c). Zinc is processed hydrometallurgical. Blister copper and nickel are produced by the Outokumpu flash smelting method. Stainless steel is manufactured from steel scrap, ferrochrome and ferronickel. Approximately, 8% of the iron and steel are produced in Finland by the scrap-based electric arc furnace process.

According to public information provided by Outokumpu oy sources, in 2014, total global steel production was 1.6 billion tonnes, of which approximately 91% was carbon steel and approximately 2.7% was stainless steel. Stainless steel is a versatile and widely used material that plays a key role in many important areas, including urbanization, transportation, energy, and the production and consumption of food, water and other beverages. Stainless steel's attractive properties, which include corrosion resistance, high strength-to-weight ratio, heat tolerance, aesthetic qualities and the ability to be recycled, have contributed to the increased use of stainless steel in new and existing applications. As a result, stainless steel consumption has been growing more rapidly than that of any other metal in recent decades.

Following table lists the major stainless-steel producers in the world. Outokumpu Oy from Finland is third in the list.

Major stainless steel producers

Estimated slab melting capacity

Million tonnes	**2014**	2015
Tsingshan	**4.4**	4.3
Tisco	**4.2**	4.2
Outokumpu	**4.0**	3.6
Posco	**3.9**	3.9
Baosteel	**3.6**	3.6
Yusco	**2.9**	2.8
Acerinox	**2.7**	2.9
Aperam	**1.9**	1.9

Source: SMR December 2014

Figure 5, Global stainless-steel producers (Source: SMR, 2014)

Outokumpu is one of the world's leading stainless-steel producers and is widely recognized for its product quality, excellence in both standard and special grades, such as duplex stainless-steel grades, and as a global leader in research, development and technical support.

2.3 CHALLENGES AND SOLUTIONS FOR DIGITIZING METAL INDUSTRY

According to Iris Group report (2015), digitalization and automation is transforming manufacturing in a number of ways, and so is the metal industry:

- Digital technologies are used to develop intelligent products that communicate with each other (Internet-of-things) and/or report back to producers in order to optimize use, maintenance and energy consumption.
- Digital technologies link companies closer to suppliers and customers allowing for closer cooperation on innovation, flows of intermediates, inventory control, adjustment to demand patterns, etc.
- Production becomes more digitalized and automated through the use of robotics and computer aided manufacturing systems that allow for leaps forward in labor productivity performance.
- Administration tasks are being automated, as well as communication between different functions in the internal value chain.

It may bring other changes that are just as dramatic as "factories" run out of somebody's garage. Digitalization in especially metal industry enables creating designs or structures that weren't feasible using the two traditional ways of making things: milling (sculpting material out of a solid block) and casting (pouring liquid material that hardens into a mold). Both techniques are greatly enhanced by mass production because quality typically rises and costs fall as volume increases. Making a lot of something also means it's not so painful to discard defective units. It enables the creation of materials with multiple parts and moving components without assembly. The process is entirely controlled by computers, following precise digital instructions, the very first piece that's manufactured is just as good as the last one. The incremental cost of producing a part becomes strictly a function of time and materials.

Increased digitalization is important to stay competitive within new business models and new types of products and production models. Thus, effective diffusion of new digital technologies will also pave the way for more effective ways to meet customer demands. It is therefore important to identify and address barriers to further digitalization and automation. Companies in the metal industry are tasked with responding to changing market demands, delivering high levels of quality, while ensuring lower operating costs. These demands force companies to evaluate and improve their business processes across the organization.

The following table lists the possible problems that current metal industry is facing and solutions to that.

Possible challenges	**Potential solutions**
High energy and raw material costs with dwindling profit margins	Effective vendor management for better cost control: with connectors to the ERP, specifications can be matched and orders generated, minimizing manual interference
Skilled manpower shortage and loss of process knowledge, due to an aging workforce	Comprehensive knowledge management to help with workforce integration: so that information is available on demand.
Stringent regulatory and environmental compliance requirements	Effective change management: enabling organization to handle sudden changes like capacity, personnel, management; establishing corporate procedures, facilitating mergers and acquisitions activities.
Lack of "off the shelf" communication and collaboration tools	
Disparate systems, leading to a longer process cycle	Efficient process automation: achieve operational efficiency and better energy utilization.
Lack of operational indicators and dashboards	
Requirements for making changes on the fly to continuously optimize grinding processes (ie, alert operators to change charge cycles, based on modelling	Comprehensive order-to-pay cycles: reduced processing time and increased visibility, to enable better margins
Lack of automated decision support systems	Better issue management and resolution: expedite troubleshooting and problem resolutions with multichannel notifications.
Need to enhance capacity to increase output on demand	Management of inventory control: track assets for optimal use, and feed preventive maintenance plans, to maximize asset health and reduce accidents and downtime

Table 1, Potential challenges and possible solutions for metal industry

To summarize, as stated by Dr Gallestey (2016), main goal for metal industry is productivity improvement. As shown in below figure industry should be moving to automated production.

To achieve the production goal, this research focuses on following two main changes.

People away from process:

Unlike traditional way, if the infrastructure would support controlling the processes remotely, it will reduce cost, increase productivity, and safety by remote monitoring, diagnostics and interventions. This remote monitoring could then be further extended to the term 'preventive maintenance'

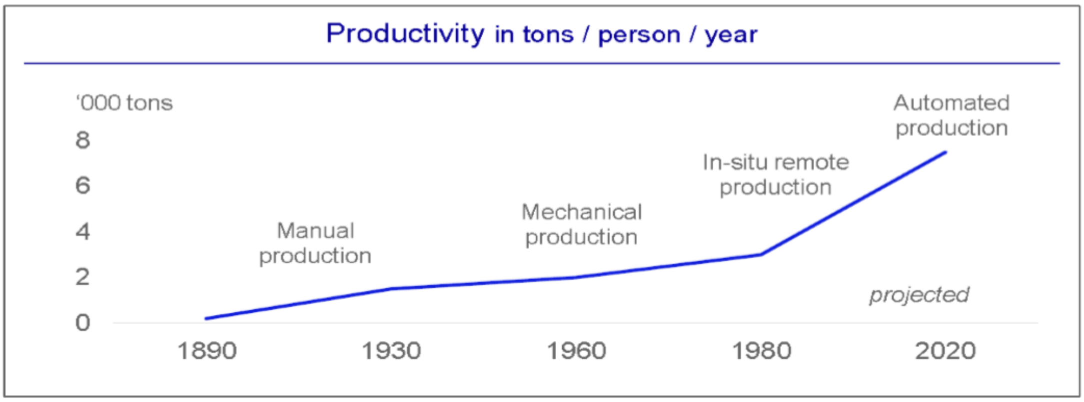

Figure 5, Productivity improvement goal for metal industry (source: ABB group)

Equipment closer to process

Increased human safety, longer and continuous working hours and high productivity could be achieved by moving automation and electricity to where the ore is extracted, minimize haulage, and transport. Usage of autonomous instruments, robotics has the potential to change the face of metal industry.

The later part of the paper discusses the customer value drivers, especially for predictive maintenance and equipment automation in metal industry, in context with IoT.

3 THEORETICAL FOUNDATION

3.1 VALUE CREATION

Scholars developing academic thought around value have developed early ideas of value and have also suggested different ways of classifying extrinsic or intrinsic value, albeit with different degrees of robustness. Mattsson (1992), for example, suggests that intrinsic value is analogous to an emotional dimension of value, whilst extrinsic value could have practical and logical dimensions. Consequently, a chair has the practical dimension of a 'seat' and has the logical dimension of 'width, size or height', but could also have some emotional dimension of being 'great-grandpa's chair', all of which contribute to the individual's perception of why the chair is 'good'. Hartman (1967) introduces a further dimension – that of 'systemic value' – where the characteristics of the thing that is good has finite properties defined by a system, or the norm. Thus, according to Hartmann's conceptualization, a chair is only good if it can seat a person without falling over, since all good chairs share the same property. The idea of extrinsic value echoes early ideas developed by Marx (1867), where not only is the item purposeful, the value of it can only be realized in context. Marx described it as "value only in use, and is realized only in the process of consumption" (Marx 1867 (2001), p.88).

Context is another aspect of value that is critical to its understanding. Chandler and Vargo (2011) argue that individuals and their contexts are mutually constitutive, i.e. they are partially defined by one another (Giddens, 1979), because each individual in context is always integrating and exchanging resources with other individuals and thereby in serving other actors, there is continuous change in the context. Simultaneously, a particular context may act as a resource for an individual actor, but as a deterrent for a different actor (Emirbayer and Mische, 1998). In this way, resources 'become' resources largely as a function of the contexts in which they are embedded. Context also plays an important role due to the way objects and people are connected with one other in different ways and at different times. Individuals therefore use their socialised and embodied skills and competence to act upon objects to perform social practices in contexts. Thus, "things-in-use can be understood as mediators of human-world relationships" (Verbeek, 2006, p. 364) and its mediations are contextually driven. Other philosophers have introduced 'the script' concept and suggested that objects often have a designed script in context, which can prescribe their users' actions when they use artefacts (Verbeek, 2006). Thus, actions are the result not only of individual intentions and other persons' social structure but also of artefacts (material environments). It has been suggested that objects (and technologies) have intentions (technological intentionality), which are not the objects' fixed properties and are interpreted when the objects are embedded in a use context (Verbeek, 2006).

Aside from the notion of utility as value, there have been five further approaches to the definition of customer value in management literature over the last 25 years. The first two approaches are inherently firm-centric, whereby value is generally thought to be 'created' through a series of activities performed by the producer. In the first, value is that determined by the firm and operationalized as the economic worth of the customer (EW) i.e. how much a customer is 'worth' monetarily. Customer's value from use can be made to be equivalent to monetary exchange value chasing power, often over the customer's lifetime of purchase from the firm. Firm-centric view, considers value as perceived satisfaction of the firm's offering (PS), often measured or assessed by the firm. This stream, while focusing on satisfaction of the customer, implicitly suggests that increasing perceived satisfaction would result in repeat purchases and/or the ability to charge a higher price. In both cases, the customer is to be marketed to, and the responsibility of 'delivery' rests with the firm. These streams of literature often discuss 'adding value' to offerings by designing/redesigning and making better offerings either for exchange or for perceived satisfaction. From a 'goodness' point of view, if an offering is good, there is a quantifiable money equivalence to how good it is. The next two approaches to value consider value as a preferential judgment of the customer. This approach has resulted in conceptualizations that seek to explain how customers judge the value of an offering. In the first, value is net benefit i.e. the evaluation of outcome as the net difference between the benefits and the costs (NB), or sacrifices associated with acquiring and consuming an offering. Value is therefore implicitly created in the consumption experience. However, conceptualization of customers' benefits in this stream of literature is often limited to tangible and intangible benefits of the offering. The sacrifice component includes monetary and non-monetary factors such as time and effort needed to acquire and use the product/service to achieve the benefits. Value is mean send i.e. the evaluation of attributes offerings as means towards a goal (ME) in that it is 'a customer's perceived preference for and evaluation of those product attributes, attribute performances, and consequences arising from use that facilitate (or block) achieving the customer's goals and purposes in use situations.' (Woodruff, 1997: P.142). In the former, goodness (value) rests in an outcome evaluation i.e. 'what I get for what I give' whilst in the latter, the goodness (value) rests in the attribute evaluation in terms of the suitability of the offering's attributes for the individual's goals. Both types of value judgments are determined by the customer based on use (or potential use) experience, often termed the consumption experience. The two judgments are not thought to be mutually exclusive and are often considered simultaneously (Khalfia, 2004). One could argue that value as evaluation of attributes is nested within value as the evaluation of outcomes, since the attributes offered achieve requisite outcomes.

As claimed by Irene & Smith (2012), recent literature points to a third approach to value where value resides, not in an object, a product, or a possession but rather, in the phenomenological experience of the customer (Holbrook 1994; 1999; 2006). Holbrook defines value as an 'interactive, relativistic preference experience', thus unlike the net benefit or means end approaches, the customer is not a passive evaluator of goodness in the experience, but an active participant in its creation within the experience. This view has been adopted by the Service-Dominant Logic (Vargo and Lusch, 2004, 2008) in their discussion of the philosophical, economic and management foundations of value. Service-Dominant Logic (S-D Logic) recaptured Smith's (1776) notion of value-in-use, re-proposing that value goes beyond simply the utility of an offering to value as a co-created phenomenological experience of the beneficiary and derived with the participation of, and determined by, the beneficiary (i.e. the customer) through engagement in the process of acquisition, usage, and disposal (Holbrook, 1987). Consequently, from a S-D Logic perspective, companies cannot provide value, but merely offer propositions of value; it is the customer that determines value and co-creates it with the company at a given time and context. Thus, a company's offering, be it intangible, tangible or a combination of the two, is merely value unrealized i.e. a 'store of potential value', until the customer realizes it through co-creation in context and gains the benefit (Ng et al., 2010). It is important to note that the way S-D Logic conceptualizes customer as a co-creator of value is different from the customer as a co-producer, a central theme in past literature. Coproduction is the customer's involvement in the creation of the company's offering e.g. customers helping Apple design the next iPhone. Value co-creation in contrast, is the customer realization of the offering to obtain value-in-use (Ng et al., 2010) e.g. using the iPhone. Whilst customers are always co-creators of value in use contexts, they may not always be co-producers of the firm's offering. Essentially, value co-creation dictates that both the firm and the customer are active in the creation of value – the former through its value propositions and latter through its collaborative experience of the firm's propositions. Clearly, customers choosing to contribute to the firm's offering through co-production co-create value in doing so as well, but based on a different proposition from the firm, that of engagement and community perhaps, and create a different value from realization of that proposition. Consequently, co-production could be nested within co-creation (Vargo and Lusch, 2008). In this respect, Vargo and Lusch propose that rather than viewing value as created by a single actor, value is created as the joint integration of resources by the multiple actors associated with an exchange (Chandler and Vargo, 2011). In this way, the simultaneous exchange processes that occur across actors during service provision – which Vargo and Lusch (2004) define as resources applied for the benefit of another actor – can be seen as service-for-service exchanges (Chandler and Vargo, 2011). Through a focus on these actor-to-actor exchanges, S-D Logic points toward a complex series of mutual service providing, value-creating relationships where all actors are both providers and beneficiaries (i.e. "producers" and "consumers")

(Vargo, 2009). This complex series of value-creating 17 relationships suggests a dynamic, networked and systems orientation to value creation rather than a linear, sequential creation, flow, and destruction of value (Vargo and Lusch, 2011) Much of the recent literature in S-D Logic views value co-creating actors or entities, be they individuals, groups, organizations, firms or governments, as systems, constellations or networks of resources (e.g. Normann, 2001; Normann and Ramirez, 1994; Vargo et al, 2008; Vargo and Lusch, 2011). These systems take action, apply resources, and work with other systems in mutually beneficial ways to co-create value (Vargo et al, 2008). Principally then, both the customer and the firm can be considered to be systems, each of which is an arrangement of resources connected by a value proposition (Vargo et al, 2008; Spohrer et al, 2007; Spohrer et al, 2008).

Current understanding of value creation is that which occurs through consumption interactions i.e. acts, processes and practices that occur in the use and experience of an offering in context (Warde, 2005). It realizes both the firm's and customer's value propositions in context to create value. In order to do so, S-D Logic proposes that actors use and integrate operand and operant resources, often in partnership with other entities, termed as resource integration. Operand resources are typically tangible resources, including economic resources goods/materials, such as natural resources, that require some action on them to create value. Operant resources, on the other hand, are typically intangible resources, such as knowledge and skills, and cultural and social resources that are capable of acting on operand and other operant resources to create value. Actors integrate operand and operant resources made available to them by various given providers, through service provision, with their own personal resources in the context of their own lives, to co-create value. Arnould, Price and Malshe (2006) go further to say that the configuration of an actor's operant resources, their family relationships, commercial relationships, brand communities, imaginations, knowledge, skills and physical powers influences how they will employ their operant resources.

A firm's competitive advantage depends on its ability to create more value than its rivals (Porter, 1980). Greater value creation, in turn depends on the firms‟ ability to innovate successfully. To capture the returns from innovation, many firms strive to be technology leaders in their industry by being first to introduce new innovations to the market. A given innovation, however, often does not stand alone; rather, it depends on accompanying changes in the firm's environment for its own success (Adner, 2006). These external changes, which require innovation on the part of other actors, embed the focal firm within an ecosystem of interdependent innovations. Understanding competitive advantage in such 'innovation ecosystems', requires a change in the way in which the strategy field has traditionally approached the relationship between a firm and its external partners. Specifically, it requires an approach that extends beyond the focus on how different actors will bargain over value capture (Porter, 1980) to include an explicit consideration of the innovation challenges that different actors will need to overcome in order for value to be created in the first place.

Shifting value away from exchange towards use suggest that marketing positioning, segmentation and targeting strategies may need to consider the five elements as strategic levers. Segmentation, targeting and positioning could be based on customer or offering heterogeneity in the five elements of experience, rather than on choice or benefits. From a product perspective, in the same way individuals create value with the firm's value proposition phenomenologically through experience of the offering in context, marketing could now assist the firm in redesigning its offering to enable socio-material affordance and greater agency for value creation (Ng and Wakenshaw, 2012). Firms are starting to adapt their offerings for different affordances e.g. train companies are not just about affording the transportation of individuals, but also about how they use information technology to afford convenience to individuals to enable them to get to the train, ie using mobile apps that provide schedules and other train information. Similarly, pharmaceutical companies are starting to understand how they can contribute to the creation of well-being at home as part of their pharmaceutical products.

Value-in-use, enabled by technology, is now being co-created between multiple entities through 'value constellations' that are geographically dispersed (Normann, 2001), and in multiple partnerships that achieve value unique to individual or customer contexts. Marketing, in terms of directing the firm to propose value to customers, must therefore fully understand the value-creating system of offering, affordance, context, agency and resources and all its social, material and technological influences with other actors in the system. Understanding value in an integrated fashion would allow the understanding of such value creating constellations and how such micro contexts of value creation could emerge to inform macro structures of markets and other economic and institutional structures. For example, car, bus and rail are considered 'transportation' in a macro structure but car, supermarket-shopping, child-pickup are in the individual's micro value constellation.

Next part of the paper discusses the concept of Internet of Things, that is changing face of metal processing industry, followed by combining the discussion of value creation in context with IoT.

3.2 INTERNET OF THINGS

The Internet is not just restricted to connect people to each other through email, forums and social networking sites but it will serve as a link between devices, machines and other things through wired and wireless networks using an open standard Internet protocol (IP). (Dutton, 2014) The next movement in the era of computing is estimated to be outside the world of desktop. A new paradigm called Internet of Things has grown fast during past few years. (Botta et al., 2016) The term IoT was first pointed out by a British technology pioneer Kevin Ashton in 1999. (Ashton, 2009) As Andersson et al. (2015) explain, IoT is supposed to portray a major change in the history of the Internet as connections move beyond computing devices and start to connect billions of everyday devices from parking meters to home thermostats. According to Bogue (2014).

Internet of Things (IoT) certainly an umbrella term for a broad range of technologies, applications and use cases as they are enabled by the connection of objects and devices. There are many Internet of Things definitions based on the perspective to look at it: the application perspective, the technological perspective, the industry context, the benefits, etc. However, there is no universally agreed IoT definition.

Figure 7, Internet of things

One of the simpler definition by Vermesan (2013) is, "Internet of things (IoT) is a network of physical objects. The internet is not only a network of computers, but it has evolved into a network of device of all type and sizes , vehicles, smart phones, home appliances, toys, cameras, medical instruments and industrial systems, animals, people, buildings, all connected ,all communicating & sharing information based on stipulated protocols in order to achieve smart reorganizations, positioning, tracing, safe & control & even personal real time online monitoring , online upgrade, process control & administration". In IoT applications, physical objects have features of digital cyber and virtual technology and they can sense/actuate, be programmable, addressed and communicate with other objects or/and humans. Combining digital, cyber and virtual technology with physical objects requires collaborations and cooperation between partners from different industrial sectors and domains. In the last few years IoT has evolved from being simply a concept built around communication protocols and devices to a multidisciplinary domain where devices, Internet technology, and people (via data and semantics) converge to create a complete ecosystem for business innovation, reusability, interoperability, that includes solving the security, privacy and trust implications (Vermesan & Friess, 2016)

Ubiquitous computing, mobile computing, and wireless sensor networks are integral parts of the IoT, in the broader sense. The web search popularity for these paradigms and the IoT during the last five years, as obtained by Google search trends, is shown in below.

Figure 8, Google search trend for IoT

It clearly indicates the increased interest in IoT in last couple of years. It is likely to continue as more attention would be paid and advance IoT technologies would emerge enabling a promise future Internet. The reason for increase in significant interest in IoT as well is because there have been a large number of developments in both IoT technology and market adoption. Standardization has progressed significantly enabling globally harmonized standard for cellular IoT connectivity.

3.2.1 Recent Technology Developments

The most common connection mechanism current IoT wearable and connected consumer devices in market use is Bluetooth or similar connection from the device to the smartphone, to provide a connection to the broader internet. The smartphone here acts as a local hub between internet and IoT device.

The biggest development over the last two years has been the maturing of technologies that allow direct connectivity to end devices from a traditional base station architecture, rather than requiring a local hub. These technologies are typically referred to as Low Power Wide Area (LPWA) technologies and there are many competing standardized and proprietary solutions available or announced. This development is shown graphically in Figure below

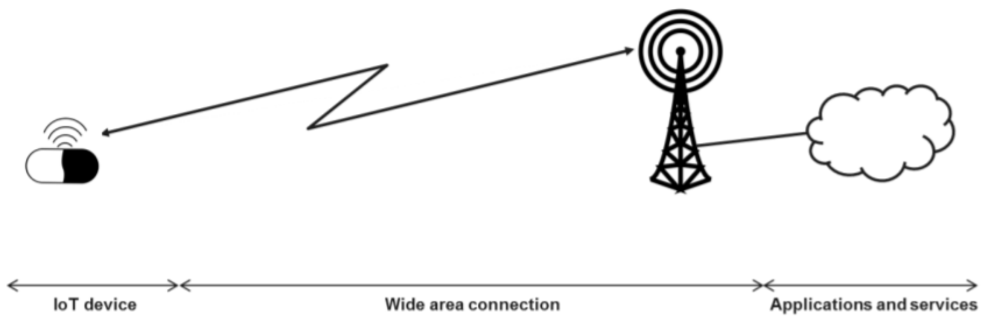

Figure 9, LPWA technology

Typically, these LPWA technologies are designed to allow terminal devices (such as parking sensors, smart meters, etc.) to operate for around 10 years on a simple battery while offering a very low cost of connection. This drive for energy efficiency means that all of the LPWA technologies offer a similar performance, with data rates of tens or hundreds of bits per second (bps) and a very limited number of messages per day. To optimize power usage, they often only activate receive mode immediately after transmission, since running receivers continuously is very energy intensive. (Winchcomb, 2017)

There has been significant development in connectivity technology and its standardization, keeping IoT in mind. eMTC (also known as LTE-M or LTE Cat-M1), NB-IoT (also known as LTE Cat-NB1), EC-GSM, Bluetooth Low Energy, 5G are few to name. It might take still several years for e.g. 5G to be deployed on large scale commercially, but beginning of the standardization activity is already a big step.

IoT integration challenges and operational issues can impact user experience and reduce confidence in IoT solutions. But there are now many providers offering elements of the IoT service chain as Platform-as-a-Service (PaaS) offerings. In these cases, specific building blocks are provided by specialists, easing the integration of a complete service.

Another key enabler is the widespread availability of cloud-based computing resource. Almost all IoT solutions require analysis of data that is collected, normally by-passing sensor readings back to a central repository. Using cloud-based services will minimize the capital exposure in data platforms, allowing any solution to scale to meet demand as it grows.

Media coverage is becoming more widespread with articles including coverage of new networks, commercial applications and how IoT can improve lives.

Activities from government backed initiatives, commercial product launches and media interest continue to raise awareness of IoT and is expected to reduce the barrier to adoption over time.

3.2.2 Industrial Internet of Things

There's an important distinction to make between the IoT as applied to the consumer space—the self-replenishing fridges, the driverless cars, the control of thermostat—and the Industrial Internet of Things (IIoT). The addition of that fourth letter alters the term to apply more to the concept of Smart Connected Operations within a plant or production facility to create products and services.

IIoT is often used to refer to the next generation on manufacturing, enabled by new computing and communications technologies, the emergence of analytics and business intelligence applications, new ways to optimize human-machine interactions and new techniques to optimize digital manufacture (such as 3D printing). IIoT provides a way to get better visibility and insight into the company's operations and assets through integration of machine sensors, middleware, software, and backend cloud compute and storage systems. Therefore, it provides a method of transforming business operational processes by using as feedback the results gained from interrogating large data sets through advanced analytics. The business gains are achieved through operational efficiency gains and accelerated productivity, which results in reduced unplanned downtime and optimized efficiency, and thereby profits.

As described by Gilchrist (2016), the Industrial Internet is a coming together of several key technologies in order to produce a system greater than the sum of its parts. The latest advances in sensor technologies, produce not just more data generated by a component but a different type of data, instead of just being precise (i.e., this temperature is 37.354 degrees). sensors can have self-awareness and can even predict their remaining useful life. Therefore, the sensor can produce data that is not just precise, but predictive. Similarly, machine sensors through their controllers can be self-aware, self-predict and self-compare. They can compare their present configuration and environment settings with preconfigured optimal data and thresholds. This provides for self-diagnostics. Sensor technology has reduced dramatically in recent years in cost and size. This made the instrumentation of machines, processes, and even people financial and technically feasible. Big Data and advanced analytics as we have seen are another key driver and enabler for the IIoT as they provide for historical, predictive, and prescriptive analysis, which can provide insight into what is actually happening inside a machine or a process. Combined with these new breed of self-aware and self-predicting components analytics can provide accurate predictive maintenance schedules for machinery and assets, keeping them in productive service longer and reducing the inefficiencies and costs of unnecessary maintenance. This has been accelerated by the advent of cloud computing over the last decade whereby service providers like AWS provide the vast compute, storage, and networking capabilities required for effective Big Data at low cost and on a pay-what-you-use basis.

IoT forms one key element of the new computing and communications technology. One promise of IoT is that it could create and redefine business models, increasing output and automating processes across a number of industries. Smart industry encompasses all areas of business, blurring and improving the divides between plant operations, supply chain, product design and demand management. Potential uses of IoT in smart industry cover device connectivity and management, data management and insights, advanced analytics, business productivity and process optimization. The use of advanced analytics allows manufacturers to predict problems and deliver value added services or even create entirely new lines of service. These analytics can be integrated into everyday tasks, workflows and business processes to improve business productivity and process optimization (O'Marah, 2015)

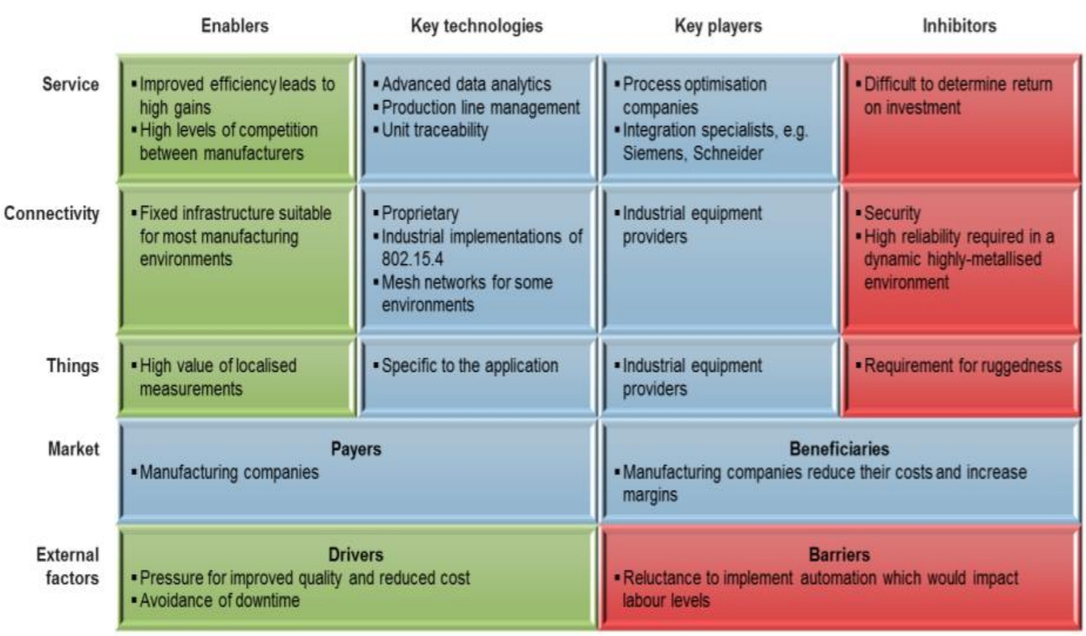

Figure 10, Ecosystem summery for IIoT (Source: Winchcomb, 2017)

Manufacturing and processing industry is relatively advanced in terms of IoT adoption and pursuing the cost savings that IoT can unlock. However, they are mainly integrating systems like asset tracking, advanced analytics and predictive maintenance, with basic functionality. Due to large upfront investment and uncertainty around return on investment, there is a lag in complex integration, such as autonomous robots and augmented reality.

Despite of that adoption of the Industrial Internet is accelerating. The number of sensors shipped has increased more than five times from 4.2 billion in 2012 to 23.6 billion in 2014(Wim, 2014)

Caterpillar and ABB are example of successful IIoT deployments. Caterpillar intends to be the leader in terms of asset management, product health, productivity, safety, sustainability and predictive analytics. By April 2016, Caterpillar had 400,000 connected assets and that number is growing. By the end of 2016 every one of their machines coming off the production line was predicted to be able to be connected and provide some form of feedback in operational productivity to the owner, the dealer or to Caterpillar (Caterpillar, 2016).

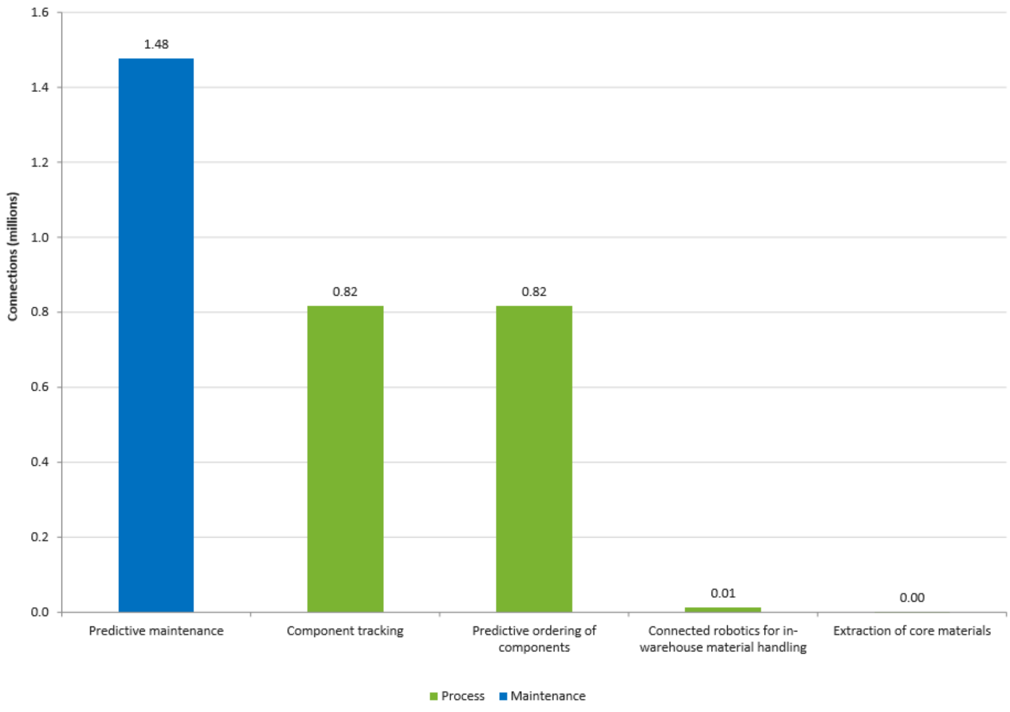

Figure 11, IIoT connections in 2024 by application (Source: Winchcomb, 2017)

The largest applications by 2024 are expected to be predictive maintenance, predictive ordering of components and component tracking. There is expected to be a limited market for connected robotics in warehouses as most warehouses do not have a business case for faster picking. Although there are relatively few connections, each can deliver high value. For example, any sensor which prevents downtime in the manufacturing process saves both the time and costs of idle equipment and workforce. One barrier to higher numbers of connections is the industry structure, in which there are many smaller companies with relatively specialist processes and potentially aging equipment and buildings.

However, increasing threat of a cyber-attack, difficulty determining return on investment, the technical difficulty of integrating IoT into a factory, and the reluctance to implement automation, which may result in job losses are the potential inhibitors for the growth of IIoT. Cyber security is an extremely important topic to manufacturers as, despite huge leaps forward in recent years, manufacturing operations remain incredibly vulnerable. This is mainly because of the legacy control systems in use in many manufacturing sites as well as connected devices opening up new avenues of attack.

3.3 IoT: Value Creation

The IoT is bridging the physical, digital, cyber and virtual worlds and requires sound information processing capabilities for the "digital shadows" of these real things. IoT applications are gradually moving from vertical, single purpose solutions to multi-purpose and collaborative applications interacting across industry verticals, organizations and people, which represents one of the essential paradigms of the digital economy. It will have a potentially significant impact on the creation of jobs and growth, along with providing opportunities for IoT stakeholders in deploying and commercializing IoT technologies and applications within European and global markets (Vermesan & Friess, 2016)

Mckinsey, based on the work on many client projects focused on IIoT, have harvested masses of relevant data for benchmarking. Drawing on this powerful combination of experience, knowledge, and insights, is built a Digital Compass that will help client to identify the most promising opportunities – along all links of supply chain – allowing to make informed decisions on which tasks to prioritize.

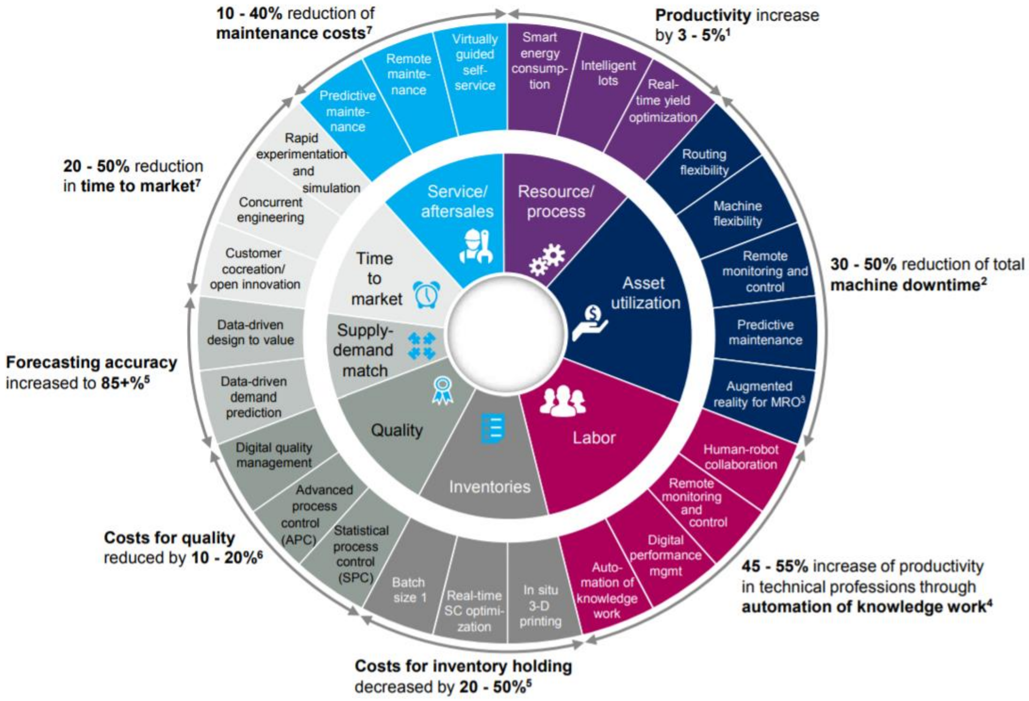

Figure 12, Digital compass (Source: Mckinsey)

The center of the compass are the eight main value drivers to push digitization across processing industry.

Mapping these value drivers to the most relevant for challenges described in chapter 2 in Finnish metal industry the important ones are

- Predictive maintenance – Predictive maintenance involves using sensors to monitor machinery continuously to avoid breakdowns and determine when maintenance will be required, rather than relying on regularly scheduled maintenance routines. IoT can improve inventory management by automatically restocking parts bins based on weight or height data recorded by sensors. It eradicates unplanned downtime and costly repairs. Connected plants use remote sensors to forecast and report on the condition and performance of machinery. Early signs of problems are detected and corrected, maintenance resources are directed at the areas of greatest need, and machinery availability is maximized
- Connected, automated and flexible process - Advances in technologies will reduce energy consumption by 20–30%, while lead times can be cut by 20–50% by integrating IoT and analytics in operations. With increased transparency, manufacturing and product design can become responsive to external events, changes in the supply chain and consumer demands. Depending on the type of industry and production, geographic location and maturity of adoption, factory managers can achieve cost reductions of between 5% and 30% of the total cost base by adopting a combination of

technologies, with the main drivers of value being quality, inventory, asset utilization, employee productivity and maintenance (Kearney, 2015)

Data is the central part of IoT. The accumulated data by attached sensors and analyzing it with AI and smart algorithms will allow more real-time and faster data-driven decision-making among leaders. For example, using digital twin tools, companies can simulate actions and explore complex trade-offs in real time before making a decision and they can monitor feedback results (e.g. digital twin for capital projects, simulation for sourcing decisions).

These are mainly efficiency and productivity focused value drivers. However, IoT also opens enormous revenue streams, if the value creation focus is changed and new business models are developed.

IoT ecosystems offer solutions comprising of large heterogeneous systems of systems beyond an IoT platform and solve important technical challenges in the different industrial verticals and across verticals. This requires a new approach around value creation and capture, the monetization of end-users value as presented in below figure.

		TRADITIONAL PRODUCT MINDSET	INTERNET OF THINGS MINDSET
VALUE CREATION	Customer needs	Solve for existing needs and lifestyle in a reactive manner	Address real-time and emergent needs in a predictive manner
	Offering	Stand alone product that becomes obsolete over time	Product refreshes through over-the-air updates and has synergy value
	Role of data	Single point data is used for future product requirements	Information convergence creates the experience for current products and enables services
VALUE CAPTURE	Path to profit	Sell the next product or device	Enable recurring revenue
	Control points	Potentially includes commodity advantages, IP ownership, & brand	Adds personalization and context; network effects between products
	Capability development	Leverage core competencies, existing resources & processes	Understand how other ecosystem partners make money

Figure 13, IoT mindset shift (source Vermesan et el, 2016)

The disruptive nature IoT needs to access the requirements with respect to future deployment across the digital value chain, in various industries and in many application areas. It must consider even better exchange of data, the use of standardized interfaces, interoperability, security, privacy, safety, trust that will generate transparency, and more integration in all areas of the internet i.e. consumer, business and industrial.

IoT will generate even more data that needs to be processed and analyzed, and the IoT applications will require new business models and product-service combinations to address and tackle the challenges. The challenge for IoT stakeholders and the IoT ecosystem is to create value for individuals or businesses. The value differs for different stakeholders: individuals can perceive value as something is "improving" their life or bring them new experiences; businesses, perceive value by ROI (return on investment), that is translated in saving company money, directly, either by lowering costs, or indirectly, by improving efficiency of existing resources, etc. Monetizing in the hyper-connected society is not limited to physical product and services, and other revenue streams are possible after the initial product sale, including value-added services, product experience, subscriptions, and apps, which in the new digital economy can exceed the initial purchase price.

Based on research conducted by World Economic Forum, 2015, evolution of the Industrial Internet will likely follow four distinct phases. Phases 1 and 2 represent immediate opportunities that drive the near-term adoption, starting with operational efficiency. Phases 3 and 4 include long-term structural changes that are roughly three years away from mainstream adoption. The outcome economy will be built on the automated quantification capabilities of the Industrial Internet. The large-scale shift from selling products or services to selling measurable outcomes is a significant change that will redefine the base of competition and industry structures.

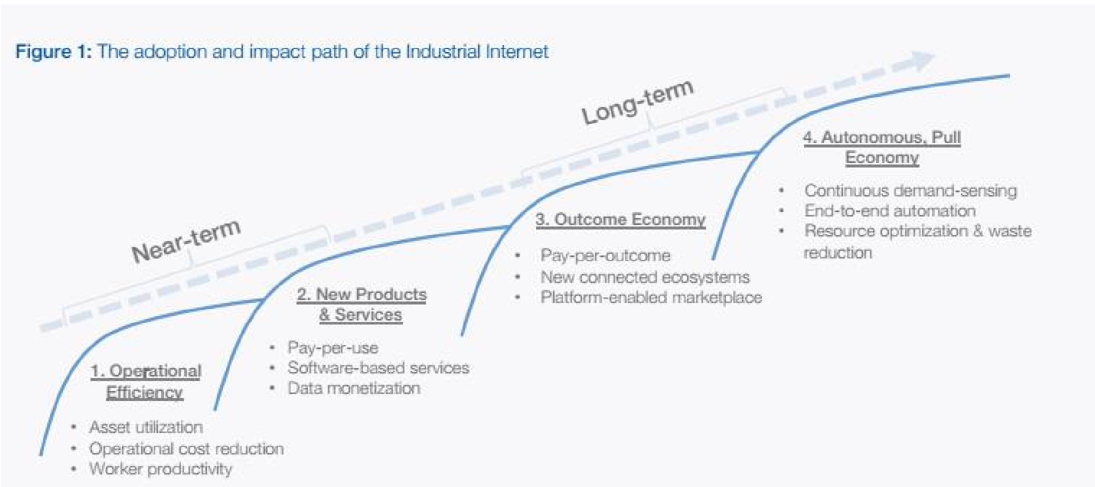

Figure 14, Adoption and impact path of the IIoT (Source: WEF, 2015)

Delivering outcomes will require companies to forge new ecosystem partnerships centered on customer needs rather than individual products or services. Because of the rising importance in data, software and platforms, incumbent players will need to expand their capabilities and ecosystems in these areas to compete in this new marketplace. As the Industrial Internet becomes more ingrained in every industry, it will ultimately lead to a pull-based economy characterized by real-time demand sensing and highly automated, flexible production and fulfilment networks (Bollier, 2015)

This development will call for a pervasive use of automation and intelligent machines to complement human labor (machine augmentation). As a result, the face of the future workforce will change dramatically, along with the skill sets required to succeed in a much more automated economy

The IoT applications in factory settings have the potential to create value of $1.2 trillion to $3.7 trillion per year in 2025. Based on research by WEF, 2015, the greatest potential for creating value will be in operations optimization—making the various processes within the factory more efficient. This includes using sensors, rather than human judgment (and human error), to adjust the performance of machinery. It also involves use of data from production machinery to adjust workflows. This is done by remotely tracking, monitoring, and adjusting machinery, based on sensor data from different parts of the plant (and even across plants). Overall, IoT applications in operations optimization have the potential to create value of $633 billion to $1.8 trillion per year in the factory setting in 2025.(Mckinsey, 2015)

4 CASE STUDY: ABB

4.1 IoTSP STRATEGY

ABB is a pioneering technology leader in electrification products, robotics and motion, industrial automation and power grids, serving customers in utilities, industry and transport & infrastructure globally. Continuing more than a 125-year history of innovation, ABB today is writing the future of industrial digitalization and driving the Energy and Fourth Industrial Revolutions. ABB operates in more than 100 countries with about 132,000 employees.

As a global leader in power and automation technologies, Switzerland-based ABB Group has installed a wide variety of power and automation equipment around the globe, ranging from motors, drives, robots and control systems to transformers, high-voltage and medium-voltage breakers, and low-voltage equipment. Connecting these devices and systems to communicate and perform the tasks required to keep its customers safe and operational is at the core of ABB's business

ABB has spent more than a decade developing and enhancing control systems, communications solutions, sensors and software in closed installations—the so-called Industrial Intranet. By enabling these installations to communicate via the Internet, and then extending with advanced Services connected to People, ABB is leading the way to advanced predictive maintenance solutions with the Internet of Things, Services, and People (IoTSP). Interconnecting things, services and people via the Internet improves data analysis, boosts productivity, enhances reliability, saves energy and costs, generates new revenue opportunities through innovative business models.

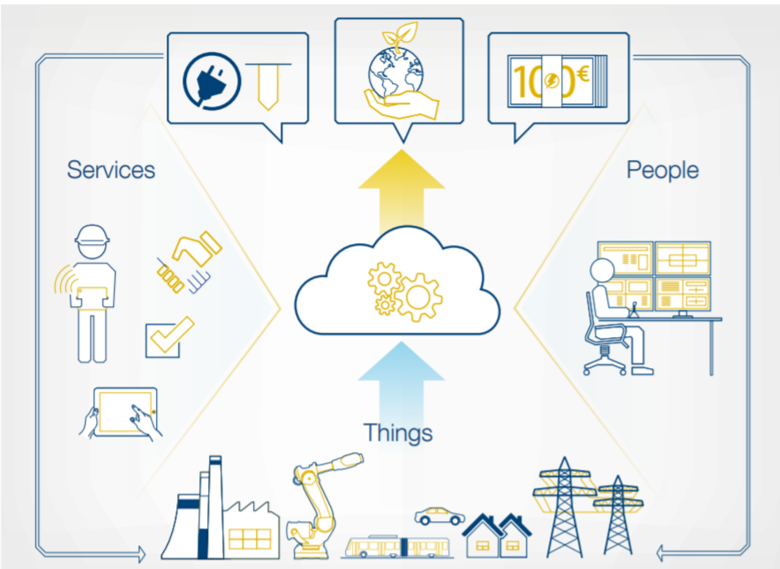

Figure 16, IoTSP strategy at ABB (source: ABB group)

In the smart factories of the future, people will control the operations and make decisions based on measurement data from the factory's equipment, as well as information regarding the availability of raw materials and the price of energy

From the figure above, elements of IoTSP could be descried as follows,

Internet: Connected devices i.e. intranet of things evolved into connected devices over internet i.e. internet of things and ultimately into internet of things, services and people i.e. all three elements integrated via internet.

Things: Things or devices are equipped with sensors, computing power and software while these things have been communicating with each other for years, IoTSP extends the communication from intranet to internet via technologies such as mobile communication and cloud software.

Services: Data analytics provides valuable clues for preemptive diagnostics and maintenance and customer benefits of these services could be substantial. IoT enables the new service model for turning identified improvements into actions.

People: People will always be crucial part of the picture. They will remain the decision makers and will program and control all production processes and activities performed by things.

Data collection and data analysis enabled by the Industrial Internet of Things may increase knowledge and allow predictions, but unless someone acts on these, there will be no effect on the operational performance and direct value to customers across various industries. Only when the knowledge is turned into actions and issues are resolved will there be a benefit from analysing more data. Providing remote access to data and analytics to service experts will close the loop of continued improvement. Online availability of support from a device or process expert is essential for a quick resolution of unwanted situations. Coupling remote access with new technologies allows earlier detection, better diagnostics, and therefore facilitates faster service – resulting in better planning and an increase in efficiency.

4.2 ABB Ability

There are not any quick fixes for organizations to adapt IIoT. However, IoT platforms are a key tool to work towards IIoT adaption and soften the challenges so that firms can keep the focus still on their core competencies. IoT platform is a complex term due to the ambiguity of the varied uses of the term by the multitude of players in the IoT market. Lucero (2016) defines an IoT platform as "cloud-based and on-premise software packages and related services that enable and support sophisticated IoT services". In some instances, IoT platforms enable application developers to streamline and automate common features that would otherwise require considerable additional time, effort and expense. In other instances, IoT platforms enable enterprises to manage thousands, millions, and even billions of devices and connections across multiple technologies and protocols. Finally, in some cases, IoT software enables developers to combine device and connection data with enterprise-specific customer and ERP data as well as data from third-party sources like social and weather data to create more valuable IoT applications

The main purpose of IoT platforms is to reduce the complexities for IoT developers, service providers, and implementers. Many, if not most, IoT applications share a large percentage of core functionality. Functions such as rules for thresholds and alerts, multiprotocol support, over-the-air firmware downloads and remote diagnostics are largely the same whether the IoT application is a fleet management service or a smart meter deployment. Much like the visible tip of the iceberg, the aspects of the IoT application that are truly unique and differentiated are typically quite a small portion of the overall application. IoT platforms therefore enable the IoT developer to focus on the differentiated and unique value the application provides and outsource common, industry-wide features and functionality. This obviously reduces time to market, needed investment and expertise, and risk.

4.2.1 ABB Ability – the Platform

ABB Ability is most discussed IoT platform supporting firms in various industries to enable IIoT. ABB ability ABB's unified, cross-industry digital platform and cloud infrastructure developed in conjunction with Microsoft, is the good example demonstrating ABB’s IoTSP strategy. ABB Ability brings together ABB’s entire portfolio of digital solutions and services, making them fully accessible and adaptable to all customers. Interconnecting things, services and people digitally - Internet of Things, Services and People - is the basis for data analysis, boosts productivity and safety, enhances reliability, and saves energy and costs. Given the size of ABB's installed base in the Internet of Things, Services and People-70 million connected devices and 70,000 control systems across a range of industries - ABB sees the potential to strengthen position as a trusted partner to customers as the Energy and Fourth Industrial Revolutions progress further, because they already know ABB and trust to deliver the right technological solutions. (US securities and exchange commission report, 2017)

ABB sees the emergence of the Industrial IoT as a 2nd wave of digitalization, building on an earlier wave centered on the services sector. As shown in figure below, most of the industries in this 2nd wave are already served by ABB.

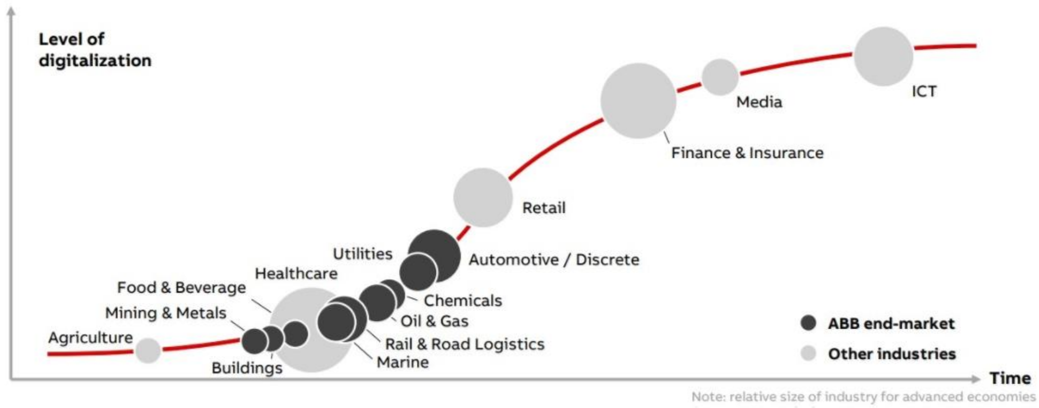

ABB Sees a "Digital S-Curve" for Industries (Source: ABB)

Figure 17, Digital S curve for ABB (Source: ABB group)

There are similarities between IoT for general systems and industrial systems, but with respect to scalability, there are also significant differences such as constraints on low latencies, criticality of the systems, requirements for predictability, resilience to failures in the system and cyber security. Hence, there is justification to specifically consider industrial IoT systems (industrial Internet, Industry 4.0). Over decades, ABB has amassed a vast pool of operational information and insights across more than 20 industries. The deep understanding of ABB's customers' industries means that they know the scientific, engineering and business reasons that underpin decisions. ABB incorporates this understanding into solutions, solving the right challenges with greater effectiveness and efficiency.

Digital offerings provided by ABB Ability include performance management solutions for asset-intensive industries; control systems for process industries; remote monitoring services for robots, motors and machinery; and control solutions for buildings, electric-vehicle charging networks and offshore platforms. Some of the more specialized offerings address energy management for data centers and navigation optimization for maritime shipping fleets, among many others.

ABB Ability's next-generation digital solutions and services are being developed and built on Microsoft's leading Azure cloud platform, based on a strategic partnership with the software company. This way, technological capabilities of Azure will be combined with ABB's domain-specific offering. In other words, in B2B context ABB is offering assistance to assess, automate, optimize and collaborate its customers by providing access to ABB's decades of industrial domain expertise, converted into software offerings that customers can access through the world's largest and most advanced digital platform.

Mission of ABB Ability is to continuously improve the collaboration between people, systems and equipment in and between plants. Following are the significant characteristics of ABB ability system that makes it stand out.

Move over to new functionalities - smoothly

With ABB Aspect Object technology, IoT technology, has an infrastructure that allows to easily attach new functions as well as replace existing functionality with new - all without changing the way things work for users.

Connect the unconnected - seamlessly

Another example is how it connects to PLCs, controllers and ERP of different brands. System 800xA has a unique cyber-physical representation of the equipment in the plant with which users can enjoy the power of having their equipment seamlessly collaborating with maintenance and video surveillance systems, even if the equipment is not controlled by ABB controllers.

Operate industrial internet - securely

Security remains the foundation for building future industrial systems based on the Internet of Things, as they are particularly exposed to physical and cyber security risks. ABB Ability™ System 800xA has the most advanced defense mechanisms in place to operate modern plants, as they move to the higher level of connectivity, mobility and networking.

Act on collected data - collaboratively

Contextual understanding of the data obtained from connected devices is the key element in adding business value from the Industrial IoT. Having information available is not helpful unless it can be acted on in a timely fashion. This could mean distributing it to individuals inside the organization, other systems in the network, other devices, or back to the device itself.

No context to the data means that we end up with a big mess (instead of big data), and the analytics can deliver the wrong result (that may look right). The Aspect object technology makes sure that all data is put into the right context and this way avoiding losing track of the information.

ABB has deep understanding of how everything works in industrial environment, in most complex processes. ABB has the expertise, infrastructure and models to transform the data into actionable information, to help customers interpret the information and drive optimization. The optimization can be either localized or systematic, and it can be manual or automated. All connected devices, systems and people need to operate in concert with each other.

ABB Ability could serve customers in utilities, industry, and transport and infrastructure. It will leverage the power of the digital revolution by enabling reduced maintenance costs, longer asset life, more efficient operations, reduced environmental impacts and improved worker safety.

4.2.2 Gränges: 40% Improvement of Strip Flatness with ABB Ability

As discussed in chapter 2, metal industry is facing challenges that drives it to find solutions to reduce costs and structure their operations more efficiently and in a more environmentally-conscious way. ABB, as a sustainable provider of electrification and process automation systems for the metal industry helps improve operating performance, asset reliability and productivity while saving energy and lowering environmental impact. Following case study is based on article published on Azom that explains how ABB ability has helped Gränges to improve productivity.

Gränges, a global leader in aluminium engineering, manufacturing and innovation, is one of the major players in rolled products, including strips for heat exchangers. ABB Ability cloud-based solutions and the ABB Stressometer Flatness Control Systems helped Gränges to achieve up to 40% improvement of strip flatness. A critical success factor for flat rolling mills is high performing flatness measurement and control. ABB's over five decades of domain expertise in flatness control, combined with latest cloud technology, modelling, computing and electronics, provides a holistic approach to strip flatness control in rolling mills. This method involves measurement and control of process variables in the actual rolling mill and in the up-stream and down-stream processes using a combination of a novel patented Stressometer technology for controlled post rolling flatness (CPRF) and the ABB Ability™ cloud-based solutions.

As discussed in earlier chapter, ABB Ability connects the power of IIoT and turns data insights into the direct action through services and expertise. Over 1,200 rolling mills across the globe make use of ABB Stressometer Flatness Control Systems for on-line measurement and control of strip flatness.(ABB Analytics & measurement). Since 1967, when the first version of the Stressometer has been introduced, it has been very popular and successful for measurement and control of flatness. Stressometer will ensure that the strip flatness out of the mill is in line with the target.

Figure 18, Stressometer for strip flatness (Source: ABB Analytics)

However, post rolling processes also affect the strip flatness and might impair the flatness from the mill. Flatness measurement is added at the end of the production process by the CPRF function. This additional measurement data is used in combination with other process data to derive a flatness target correction for the rolling mill that will negate post rolling effects on the flatness of the strip. Substantial savings are made possible through higher speed, safer rolling, optimized process flow, less strip breaks, less scrap, and less rejects from customers.

Flatness quality of rolled strip at Gränges is crucial for both the rolling processes and the post rolling processes. The use of the Stressometer CPRF function makes the follow-up and visualization of the actual strip flatness in the different processes easier. It also facilitates design of flexible quality reports on-demand with analysis of production issues. Optimized flatness target maps are produced and updated when required for all used alloys and products. As a result, Gränges achieves outstanding strip flatness in the post rolling processes.

4.3 Predictive Maintenance with GMD Monitoring

As a global leader in power and automation technologies, ABB Group has installed a wide variety of power and automation equipment around the globe, ranging from motors, drives, robots and control systems to transformers, high-voltage and medium-voltage breakers, and low-voltage equipment. ABB has always focused on connecting these devices and systems to communicate and perform the tasks required to keep its customers safe and operational. Among the devices mentioned, ABB’s robots have gained much attention among ABB’s connecting devices. It is due to the ability of the robots to provide increased efficiency and safety across a wide array of industries. However, at times the broad deployment of automation technologies creates challenges in monitoring and maintenance. ABB’s customers need to be ensured that their machines are operating efficiently, along with minimizing downtime when repairs or upgrades are needed. ABB has been able to address these challenges through innovative IoT technologies, which are used to monitor more than 5,000 devices in the field in real time. Historically, ABB had to send technicians to perform device diagnoses in person. Now, ABB offers several cloud based IoT solutions, including data aggregation, statistical analysis and remote control rooms that provide real-time monitoring of individual machines as well as longitudinal analytics that allow for accurate predictive maintenance. This proactive monitoring allows ABB and its clients to save on maintenance costs by reducing the time and effort required for upkeep, and to reduce costs associated with unexpected downtime by fixing machines before they break.

There is some debate about whether in-machine (or on-site) or cloud-based monitoring and analysis are more effective. Rather than throwing everything into the cloud simply because it's a newer application, ABB implements monitoring systems balancing these requirements, resulting in an approach capable of incorporating either or both longitudinal, cloud-based solutions and real-time localized monitoring to provide a comprehensive and effective service, depending on each client's need. ABB's gearless mill drives (GMDs) are just one example of remote monitoring at work. A powerful innovation in the mining industry on their own, GMDs provide a substantially more efficient means of grinding ore into smaller particles that are more easily processed. While these machines typically operate smoothly, grinding is an intensive process that puts extreme wear and tear on the machine. Failure can delay operations by days or weeks, resulting in substantial losses for the mining operation. With real-time GMD monitoring, ABB can alert customers in time, allowing maintenance workers time to proactively address any problems with the machine and prevent unplanned outages. This proactive monitoring allows ABB and its clients to save on maintenance costs by reducing the time and effort required for upkeep, and to reduce costs associated with unexpected downtime by fixing machines before they break. The deeper knowledge of its own machines and how they work has also enabled ABB to add value for its clients by bringing increased efficiency to related operations.

ABB also helps monitoring ships all around the world to increase fuel efficiency in real time. ABB's willingness to adjust toward new strategies and services can provide a great model for other companies looking for ways to improve their own IoT innovations

5 CONCLUSION

Finland has traditionally had two strong industrial areas, the forest industry and the metal industry. The Finnish steel and metal industry is famous for various machines, ships (both cruisers and ice-breakers) and lifting equipment, while offshore constructions are an emerging area of high competence. Smolsky (1996) describes the special features of the Finnish metal industry, and she concludes that "Finnish companies have established a reputation for versatility, productivity and quality". Nonetheless, when Finnish companies are operating globally they are many times smaller than their competitors. The Finnish metal industry has a wide range of customers including mechanical engineering, construction and the automobile industry, as well as shipbuilding, consumer goods, and leisure product industries. Today the emphasis is on know-how as well as the efficient utilization of information technology, automation, and new technologies in order to increase the amount of processed metals.

Finland like other Nordic countries has always been ahead of time when it comes to industrial digitization. According to a report by Iris Group (2015), Nordic countries have several positive preconditions for faster and better implementation of digital technologies:

- Digital skills - A higher fraction of people in the Nordic countries have "above basic" digital competence when it comes to digital information, digital communication, digital content-creation and digital problem solving (European Commission, 2014)
- Digital readiness - INSEAD and World Economic Forum have developed an index that measures the ability of individual countries to take advantage of ICT and digital technologies. It consists of 53 ICT-related indicators within areas like skills, ICT-usage, infrastructure and regulation. Among 143 countries, Sweden, Finland and Norway are ranked in top 5 (INSEAD &WEF, 2015)
- Research and development - High investments in research and development are important in order to develop and implement digital technologies. The Nordic countries are among the leaders in private research and development (compared to GDP) with Finland and Sweden placed in top 5.
- Broadband coverage - The Nordic countries are among the top when it comes to number of fixed and mobile broadband subscription per inhabitants, 2014 (OECD, 2014)
- Culture and work place organization - Optimal use of digital technologies is closely linked to intra-organizational cooperation, production in small batches, close link to customers, etc. Hence, the Nordic model characterized

by an informal work place culture and low power distance might represent an important competitive advantage (Morgen, 2009)

- Strong ICT-sectors. The ICT sectors share of value added and total private employment are high in the Nordic countries (especially Sweden and Finland) ((European Commission, 2014)

However, these advantages are not automatically transferred into faster digitalization and automation, especially in traditional industries like metal and mining. Technologies such as robots, 3D printing and smart sensors offer opportunities for metals companies to revolutionize their operations and create significant value. The use of automation and robotics, digitally enabled hardware tools to take over activities traditionally carried out by human-controlled machinery, is already growing within the metals industry. Important technologies in this area include 3D printing; automated exploration drones; robotic trucks, trains and diggers; autonomous stockpile management; autonomous robots for recovery of recycling material; and pit drones. These technologies are expected to be deployed more widely as their capabilities improve and cost drops. This digital theme looks at condition monitoring, predictive forecasting and reliability-centered maintenance, all enabled by analytics and robotics.

Following are the two conclusions derived from the discussions and case studies in this paper.

- Advanced digitization of metal industry with IoT is feasible and successful as demonstrated with case study 2, and it is also the solution to the major problems discussed at the end of chapter 2, regarding Finnish metal industry.
- For the Finish metal industry which is dominated by SMEs, IoT platforms like ABB Ability is one of the faster ways to jump into the further digitization train of IoT

Following part of this chapter discusses these conclusions in more detail.

The summery of second chapter identifies two major enablers for IoT in Finnish metal industry, predictive maintenance and autonomous operations.

Predictive maintenance

Maintenance is a process for which the objective is to keep the equipment in a working, efficient and cost-effective condition. The maintenance process is conducted by performing the necessary actions on the equipment to achieve one or more of these objectives. These actions include, but are not limited to, inspection, tuning, repair, and overhaul of the equipment or its components. Predictive maintenance is a maintenance strategy that depends on monitoring the condition of the equipment in order to determine the right maintenance actions that need to be taken, at the right time. Predictive maintenance has many advantages over other strategies such as corrective and preventive maintenance as it reduces the chance of unexpected failures, increases the equipment availability, and accordingly, decreases the overall cost of the maintenance process.

Predictive maintenance creates obvious economic value for the organization, as is clearly visible form case study2 and claimed by Deloitte Analytics Institute (2017) as well, as shown in below figure.

Figure 19, Economic value creation with Predictive maintenance (Source: Deloitte Analytics Institute (2017))

Although benefits of predictive maintenance are dependent on the industry or even the specific processes that it is applied to, analytics have concluded that material cost savings amount to 5 to 10% on average. Equipment uptime increases by 10 to 20%. Overall maintenance costs are reduced by 5 to 10% and maintenance planning time is even reduced by 20 to 50% (Deloitte Analytics Institute, 2017). The profit of predictive maintenance increases with the underlying maintenance costs. The higher the expenses caused by failure the bigger the benefits

The obvious benefit of predictive maintenance is, it maximizes runtime. Repairs can be carried out just before a breakdown. That represents a major advantage. Studies show that unplanned downtime is costing industrial manufacturers an estimated $50 billion each year (Industry Week, 2017). Also, necessary maintenance efforts can be orchestrated to minimize system-wide downtimes. Predictive maintenance can further be used to ease logistics by maintaining machines at convenient times – for example outside of production hours or while the needed personnel is close by. Lastly, it can assist purchase departments by predicting which spare parts will be needed at which point in time.

Autonomous operations

According to WEF report (WEF, 2017), Greater use of autonomous machines could create $56 billion of additional value for the industry, through an increase in output, since they can operate 24 hours a day, 365 days a year at a constantly high productivity level. In both mining and metals, increased automation will create value for the industry through reduced personnel. The bulk of this value ($47 billion) to be created, where automation can have a particularly significant impact in the extraction phase. Some tasks can also be performed more efficiently by machines than humans (e.g. drones for exploration).

Autonomous operations can increase worker safety, especially in extreme conditions such as those found in underground mines or hot mills, reducing the number and severity of health and safety incidents. In mining, estimation is that about 120 lives will be saved and approximately 7,000 injuries avoided over the next decade. In metals, roughly 130 lives could be saved and an estimated 3,000 injuries avoided.

Experts from WEF report (2017) estimate that wider adoption of autonomous operations is likely to displace approximately 60,000 mining jobs (or 4% of the total) over the next 10 years, as fewer personnel are needed to supervise operations carried out by intelligent machines and robots. This could be particularly detrimental for local communities in remote areas where mines are one of the few employers.

Greater operational efficiency is expected to reduce CO_2 emissions by approximately 400 million tonnes over the next decade. The bulk of these emissions savings (about 340 million tonnes) to come from the mining industry, where autonomous machines consume less fuel than manual ones. In the metals sector, reduced energy consumption in automated processes will save roughly 60 million tons of emissions. (WEF report, 2017)

Following figure shows the value-at-stake by autonomous operations and robotics in metal and mining industry (cumulative 2016- 2025)

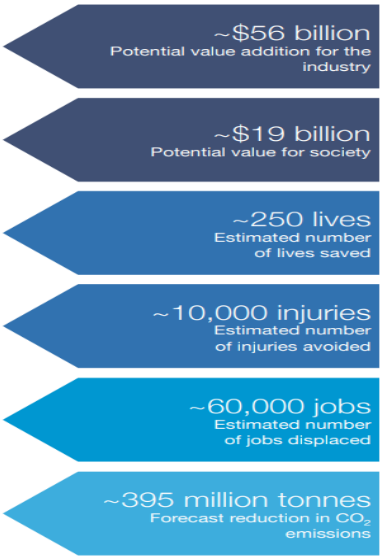

Figure 20, value-at-stake by autonomous operations and robotics in metal and mining industry (cumulative 2016- 2025): Source World Economic Forum Report (2017)

Apart from the economic value created by IoT in metal industry, IoT also opens enormous opportunities to develop new business models and expansion of businesses. By augmenting the degree of intelligence in products, people and services, IoT will require companies to change and adapt their product portfolios to new realities, thereby creating the potential for new leaders and laggards to emerge across all industries. So, to summarize, IoT in metal industry can bring following keys values, as also supported by PWC report (2017),

- Higher revenues: There are three categories of businesses that will benefit from increased revenues due to the combination of the IoT with smart sensors: firstly, IoT device manufacturers; secondly, IoT data and information providers/aggregators; and thirdly, companies offering application services based on smart sensors.
- Enhanced safety: Real-time monitoring will prevent disasters from occurring and hence raise overall safety.
- Reduced losses from accidents and other causes: Real-time monitoring will reduce loss of lives and damage to assets.
- Lower costs: Smart monitoring of devices, electricity grids, home smart meters, or even sensor enabled domestic appliances, will result in lower operating costs for homes and businesses.
- Enhanced customer experience: Smart sensors can adjust to the individual behaviors of users/ consumers by learning their preferences.

IoT platform for SMEs in Finnish metal industry

Fundamentally, an IoT platform connects devices, applications, and data so that users can focus on their use case rather than on the wiring linking the various platform components. A comprehensive IoT platform delivers three main capabilities: application enablement (to customize IoT solutions), data aggregation and storage (to capture and store data that will generate insights), and connectivity management (to automatically connect systems, networks, and devices) IoT platforms have a natural link to digitalisation. Standardization helps also in production of physical goods. But when data, algorithms and apps are reused it does not require deconstruction of the original goods. The optimal use of information, including data, databases, information, metadata, algorithms, codecs, learning algorithms, apps, programs and scripts is much more efficient when the platform is digital even though the product or service is physical.

As mentioned in earlier chapter, Finnish metal industry is dominated by SMEs. and according to a recent VDE study only 3 out of 10 SME's are riding the waves of IoT (VDE, 2016). While SMEs might see and believe in the Internet of Things potential it is not really translating into actions. On the other hand, companies that want to reap the full potential of IoT through in-house innovation must overcome a variety of inhibitors and obstacles that are slowing down IoT adoption considerably.

According to Lueth & Glienke (2017), The biggest obstacles for SMEs today is the lack of internal talent and lack of technology expertise. Both would be a must-have for internal development. SMEs looking to find talent and expertise in IoT immediately compete on a global scale - a competition they seem unlikely to win as many SMEs are located in lesser known areas with less attractive settings for a globalized workforce. As indicated in the figure below, According to the survey report by (Lueth & Glienke , 2017), 46% of SMEs lack internal talent and 40% lack technology expertise. This is a vast skill gap that SMEs will have to bridge on the path to digital transformation and innovation in IoT. Limited R&D budget as well is one of the major obstacles.

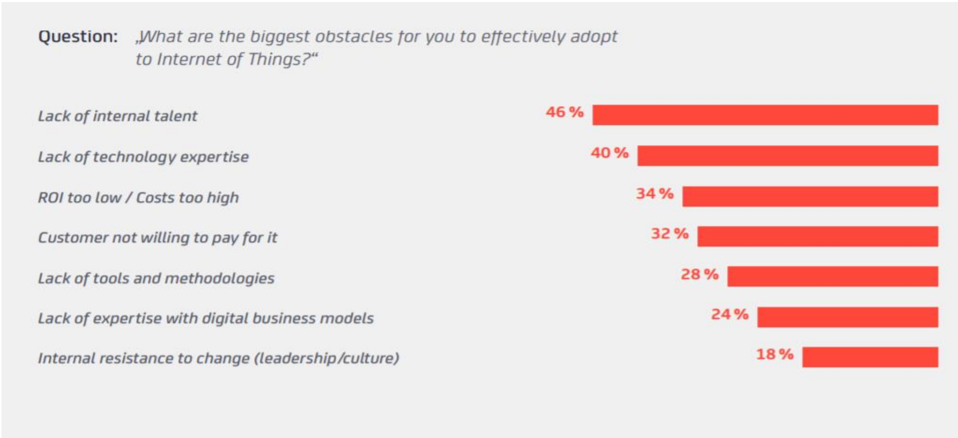

Figure 20, Obstacles for SMEs to adopt IoT (Source: Survey by Innovation Performance, September 2017)

In order to develop new and potentially disruptive services in an increasingly service-driven environment, experts in digital transformation, innovation, and IoT are needed. A lack of talent and expertise would otherwise lead to a lack or at the very least a detrimental delay of products and services for the future. To avoid delayed innovation, many SMEs opt for external means of transformation and innovation.

IoT platforms like ABB Ability discussed in case study is one easier way for SMEs for faster adoption of IoT. IoT platforms abstract lot of functionality and provide all the basic work needed for device connections and extracting data. Platforms provide some ready-to-use applications as discussed in the case study and provide the way to develop and deploy very own specific application for SMEs. This needs lesser number of skilled resources, less investment and easier maintenance. Smart sensor provided by ABB ability platform is one of the very good example for SMEs to use as the starting point for IoT adoption. Smart sensor can be attached to existing motors, needing less or no changes to running setup and predictive maintenance could be enabled for that motor. Data from the Smart Sensor are transferred wirelessly to a secure ABB server. The data is processed by algorithms, developed by ABB, to produce meaningful information. The information is then made available to the motor user. The intuitive user interface includes a simple "traffic light" system that provides an overview of the monitored motors.

There are still concerns about data security, privacy, regulatory standards when it comes to IoT deployments for SMEs, however the clouds around those will disappear with more and more successful deployments.

Recent developments in IoT has opened lots of opportunities, especially in manufacturing and processing industries. At this point although main objectives for organizations is to achieve economic value created by IoT, in near future it will enable new business models and will change the face of industries like metal and mining.

REFERENCES

Adner, R. 2006. Match your innovation strategy to your innovation ecosystem. Harvard Business Review, 84(4): 98- 107

Airaksinen, Timo, 1992. Kansallis - Osake - Pankki. Economic Review 1 : What Will EC Membership Mean for Finland's Metal and Engineering Industries?

Alasdair Gilchrist Bangken, 2016. Nonthaburi Thailand ISBN-13 (pbk): 978-1-4842-2046-7 ISBN-13 (electronic): 978-1-4842-2047-4 DOI 10.1007/978-1-4842-2047-4 Library of Congress Control Number: 2016945031

Andersson, P., Mattsson, L., Markendahl, J. 2015. Service innovations enabled by the "internet of things". IMP Journal 9, 1, pp. 85 – 106.

Arnould, E. J., Price, L. L. and Malshe, A., 2006. Toward a cultural resource-based theory of the customer, in Lusch R. F. & Vargo S. L (Eds.) The Service-Dominant Logic Of Marketing: Dialog, Debate And Directions, ME Sharpe, Armonk, NY, pp. 320−333.

Ashton, K. 2009. That 'Internet of Things' Thing. RFID Journal. Available at: http://www.rfidjournal.com/articles/view?4986. Accessed: 29.11.2015

A.T. Kearney, 2011. Building a Capability-Driven IT Organization The road to growth, flexibility and innovation

A.T. Kearney, 2010–2015. Factory of the Year, Global Excellence in Operations.

Boesenberg (SISAX-M), Anne Hoeer (SISAX-M), Michele Osella (ISMB), 2014-2015. IoT Business Models Framework , H2020 Work Programme 2014-2015.

Bogue, R. 2014. Towards the trillion sensors market. Sensor Review 34, 2, pp. 137 – 142.

Bollier, David, 2006. When Push Comes to Pull: The New Economy and Culture of Networking Technology. The Aspen Institute. Available at-http://www.aspeninstitute.org/sites/default/files/content/docs/cands/2005InfoTechText.pdf

Botta, A., Donato, W., Persico, V., & Pescape, A. 2016. Integration of Cloud computing and Internet of Things: A survey. Future Generation Computer Systems 56, pp. 684 – 700.

Britten N., 1999. Qualitative interviews in healthcare. In Pope C, Mays N (eds) Qualitative research in health care. 2nd ed. pp 11–19. London: BMJ Books.

Case study from ABB Measurement & Analytics, 2017. Provided ABB group, available at – https://www.azom.com/article.aspx?ArticleID=14991

Caterpillar (CAT) Earnings Report: Q1 2016 Conference Call Transcript.", TheStreet, April 22 2016 Issue

David M. & Scott and Hugh McCann, 2005. Process Imaging For Automatic Control, Print ISBN: 978-0-8247-5920-9 eBook ISBN: 978-1-4200-2819-5

Derek du Preez, April 2016, Press release from Caterpillar CEO, available at-https://diginomica.com/2016/04/25/caterpillar-ceo-we-have-to-lead-digital-by-the-summer-every-machine-will-be-connected/

Dimitris Bibikas, Tim Vorley, Robert Wapshott, 2017. Pan-European Entrepreneurial Summer Academies with Impact: The Case of STARTIFY7, Emerald.

Dosi, G., R. R. Nelson, and S. G. Winter, 2000. Introduction: The Nature and Dynamics of Organizational Capabilities, Oxford: Oxford University Press, 1–22.

Dr Eduardo Gallestey, 2016. Global Technology Manager Process Industries, ABB, Optimizing process industries in digital era

Dr. Ovidiu Vermesan, 2013. SINTEF, Norway, Dr. Peter FriessEU, Belgium, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", river publishers' series in communications.

Dutton, W. H., 2014. Putting things to work: social and policy challenges for the Internet of things. Info 16, 3, pp. 1 – 21.

Emirbayer, M. and Mische, A., 1998. What is Agency?, The American Journal of Sociology, Vol. 103, No. 4, January, pp. 962-1023.

Elfrink, Wim, 2014. Blog on, 'The Internet of Things: Capturing the Accelerated Opportunity', available at- http://blogs.cisco.com/ioe/the-internet-of-things-capturing-the-accelerated-opportunity

European Commission, 2014. Digital Agenda Scoreboard

European Commission, 2014. The EU ICT sector and its R&D performance, "How Manufacturers Achieve Top Quartile Performance", Industry Week & Emerson, Partners.wsj.com

Giddens, A.,1979. Central Problems In Social Theory: Action, Structure And Contradiction In Social Analysis, University of California Press, Berkeley and Los Angeles, California.

Gray, Neil, Andrew Kyllo, and James Coveney, 2005. Applications in the Metals Production Industry , Electrical and Computer Engineering.

Gummesson, 1993. CASE STUDY RESEARCH IN MANAGEMENT: Method for Generating Qualitative Data. Stockholm, Sweden.

Hartman, R. S. ,1967. The Structure of Value, Southern Illinois Press, Carbondale,Illinois

INSEAD and World Economic Forum, 2015. The Global Information Technology Report.

Irene C.L. Ng, Laura A. Smith, 2012. "An Integrative Framework of Value" , Emerald.

Johnson, Eva Liedholm, and Magnus Ericsson, 2015. State ownership and control of minerals and mines in Sweden and Finland, Mineral Economics.

Johannes Köper, Hans J. Zaremba, 2012. Quality Management and Qualification Needs 1: Quality and Personnel Concepts of SMEs in Europe.

Kevin O'Marah, 2015. Article in industry week on, The Internet of Things Will Make Manufacturing Smarter, available at- http://www.industryweek.com/manufacturing-smarter?page=1

Khalifa, A. S., 2004. Customer value: A review of recent literature and an integrative configuration, Management Decision, Vol. 42, No. 5, pp. 645−666.

Knud Lasse Lueth, Dirk Glienke and Zaña Diaz Williams, 2017. GUIDE TO IOT INNOVATION (SME FOCUS) Achieving Innovation Performance, available at –

https://iot-analytics.com/wp/wp-content/uploads/2017/09/Guide-to-IoT-Innovation-SME-Focus-September-2017-vf.pdf

Mandag Morgen, 2009. Scandinavian management model makes good bottom lines.

Marx, K., 1867 [2001]. Capital: A critique of political economy. Penguin Books in association with New Left Review, Harmondsworth, Middlesex, England.

Mattsson, J. ,1992. A service quality model based on an ideal value standard, International Journal of Service Industry Management, Vol. 3, No. 3, pp. 18-33.

May K M., 1991. Interview techniques in qualitative research: concerns and challenges. In Morse J M (ed) Qualitative nursing research, pp 187–201. Newbury Park: Sage Publications.

Note from Strategic Product and Innovation Communications, ABB, 2016. About IOTSP strategy, available at - http://new.abb.com/docs/librariesprovider138/Hannover-Messe-2016/iotsp_positioing_en_1.pdf?sfvrsn=4

OECD, Broadband Portal.

O. Vermesan and P. Friess, 2016. Digitising the Industry - Internet of Things Connecting the Physical, Digital and Virtual Worlds, ISBN: 978-87-93379-82-4, River Publishers, Gistrup.

Ovidiu Vermesan (SINTEF), Roy Bahr (SINTEF), Alex Gluhak (DIGICAT), Frank ICT-30-2015: Internet of Things and Platforms for Connected Smart Object

Porter, M. E. 1980. Competitive Strategy: Techniques for Analyzing Industries and Competition. New York: The Free Press

Press release from ABB Group, March 2017. Available at - http://www.abb.com/cawp/seitp202/fb65141e5556c69d442580e40020ef57.aspx

Report from Association of Finnish Steel and Metal Producers, Kimmo Järvinen, 2016. Available at - http://www.teknologiateollisuus.fi/en/technology-finland/metals-industry

Report from Iris group, 2015. On "Digitalisation and automation in the Nordic manufacturing sector – Status, potentials and barriers", Iris Group, ISBN 978-92-893-4422-7 (PDF) ISBN 978-92-893-4408-1 (EPUB) ISSN 0908-6692, available at-

http://norden.diva-portal.org/smash/get/diva2:876658/FULLTEXT01.pdf

Report from Mckinsey global institute, June 2015. On ‘The internet of things: mapping the value beyond hype’, available at

https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/The%20Internet%20of%20Things%20The%20value%20of%20digitizing%20the%20physical%20world/The-Internet-of-things-Mapping-the-value-beyond-the-hype.ashx

Report from Deloitte Analytics Institute, Issue 7/2017. On Predictive Maintenance | Position Paper Available at –

https://www2.deloitte.com/content/dam/Deloitte/de/Documents/deloitte-analytics/Deloitte_Predictive-Maintenance_PositionPaper.pdf

Report from PWC, 2017. On Leveraging the upcoming disruptions from AI and IoT, available at- https://www.pwc.com/gx/en/industries/communications/assets/pwc-ai-and-iot.pdf

Report on Finnish metal industry, 2014. available at –

http://teknologiateollisuus.fi/en

Robert S Schimek, 2015. IoT Case Studies: Companies Leading the Connected Economy, American International Group, Inc

Sam Lucero 2016, IHS TECHNOLOGY IoT platforms: enabling the Internet of Things

Smolsky P., 1996. Small, specialized and export led. Steel Times International 20 (5) 22-30.

Tellis, Winston,1997. Introduction to Case Study. The Qualitative Report, Volume 3, Number 2, July. Available at- http://www.nova.edu/ssss/QR/QR3-2/tellis1.html).

Tim Winchcomb, Sam Massey, Paul Beastal, P2952-R-001 v4.8, "Review of latest developments in the Internet of Things", Ofcom contract number 1636 (MC370)

UNITED STATES SECURITIES AND EXCHANGE COMMISSION Washington, DC 20549, REPORT OF FOREIGN PRIVATE ISSUER PURSUANT TO RULE 13a-16 OR 15d-16 UNDER THE SECURITIES EXCHANGE ACT OF 1934 For the month of May 2017 Commission File Number 001-16429

Vargo, S.L. and Lusch, R.F., 2011. It's all B2B…and beyond: Toward a system's perspective of the market, Industrial Marketing Management, Vol. 40, pp. 181-187.

VDE-Trendreport, 2016. On Internet der Dinge / Industrie 4.0, available at - https://shop.vde.com/en/vde-trendreport-2016-internet-der-dinge-industrie-40

Verbeek, P.P, 2006. Materializing morality: Design ethics and technological mediation, Science Technology Human Values, May, Vol. 31, No. 3, pp. 361-380.

Vladimir Miodrag Cvjetkovic, 2018. Chapter 66 IoT Teaching with Pocket Labs, Springer Nature.

World economic forum report in collaboration with Accenture on 'Industrial Internet of Things: Unleashing the Potential of Connected Products and Services' available at http://www3.weforum.org/docs/WEFUSA_IndustrialInternet_Report2015.pdf

Woodruff, R.B., 1997. Customer value: The next source for competitive advantage, Journal of the Academy of Marketing Science, Vol. 25, No. 2, pp. 139- 153.

www.OutoKumpu.fi

www.new.abb.com - ABB Group

Yin, R. K., 1984. Case study research: Design and methods. Newbury Park, CA: Sage.